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NOISE REDUCTION TECHNOLOGY

HEARING

BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

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NOISE REDUCTION TECHNOLOGY

MONDAY, APRIL 1, 1985

HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE AND TECHNOLOGY, SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS,

Washington, DC.

The subcommittee met, pursuant to call, at 9:30 a.m., in the County Commission Chambers, Governmental Center, 301 North Olive Avenue, West Palm Beach, FL 33401, Hon. Dan Glickman, Chairman of the committee, presiding.

Present: Representatives Glickman, Lewis, and Packard.

The CHAIRMAN. Shall we begin?

First of all, the subcommittee would like to thank very much the County Commission of Palm Beach County for allowing us the opportunity to use this facility, and also for the opportunity to bring this subject matter to this part of the country where aircraft noise has been such an important issue.

I understand the chairman of the County Commission, Mr. Ken Adams, is here. Mr. Adams, we want to thank you for allowing us this opportunity, and on behalf of myself and Mr. Tom Lewis, the ranking member on this subcommittee, we are most appreciative that we are able to talk about this issue here in your part of the State.

Mr. ADAMS. We are very pleased to welcome you, Chairman Glickman, ranking minority member Congressman Tom Lewis and Congressman Ron Packard from San Diego.

I would like to take just a moment to thank a prior chairman of the County Commission, Ken Spillias, who has done a great job for about 2 years, working with the noise abatement program in Palm Beach County.

Our airport is absolutely essential to Palm Beach, economically, but unfortunately it happens to be downtown, as well, and there is a conflict.

I think that what you're going to find as you evaluate our program is most everything in the program has been done somewhere before, but to our knowledge, not all of it has been packaged together in one effort anyplace else in the country.

We are very proud of it, and we are very pleased to welcome you to come here to Palm Beach County.

The CHAIRMAN. Thank you very much, Mr. Adams.

Mr. Lewis, would you have any comments at this stage?

Mr. LEWIS. Thank you, Mr. Chairman, and before I make any comments, I would like to introduce to everyone our Florida

Cherry Blossom Princess, Ms. Kathleen Mead. Kathy, why don't you stand up and let everybody see you.

Ms. MEAD. Hello.

Mr. LEWIS. Kathy will be going to Washington in another week, and she will be up there for the Cherry Blossom Festival, so she will certainly be a great ambassador for us.

Mr. Chairman, I want to thank you, especially, for graciously agreeing to hold these hearings here in West Palm Beach. As you know, the subject of these hearings is of special interest to our citizens here, and I'm sure they're anxious to hear what progress is being made to reduce airport noise.

In a civilized society such as ours, we have come to expect continued improvements in the quality of life through technological advances. However, we also have come to realize the technology that brings us a higher standard of living often brings with it new problems.

This has certainly been true with aviation, and how we address these problems is up to us. Few people realized back in 1903 that the Wright brothers accomplishment would have such a profound effect on our lives.

Today, for many people, when you add up the time driving to the airport, waiting for your plane, then at the other end waiting for your car and then finally driving to your destination, the coast-to-coast flight is the short part of the trip.

If we think mail is slow today, we can only imagine what it would be like without the airplane. Not only has aviation made the other parts of the world closer to us in time, but the ease with which we can travel to other parts of the world has tended to fade cultural differences as well.

I think very few of us would want to return to the days before the airplane. In fact, more people than ever are flying. Today, approximately 70 percent of the U.S. adults have traveled by air, and most of this air travel is pleasure travel.

This is important to this community. Tourists spent over a billion dollars in Palm Beach County last year, and as my colleagues can attest, it's not always easy to get a flight to West Palm Beach, particularly at this time of the year.

Although many who pass through Palm Beach International are tourists, the airport is also the main air terminal for my congressional district, a district which is rapidly growing and has increasing demands for air travel.

Last year nearly 2 million passengers deplaned at PBI. That was an increase of 5.3 percent over the previous year, and with continued economic growth predicted, there is every reason to expect this to increase again this year.

This is good news for the economy of West Palm Beach. Aviation, and in particular the activities at our local airport, have had a major impact on the economy of this community. However, there have also been problems.

Not the least of these problems has been airport noise, and even those among us who rely most heavily on air travel, are not willing to accept unlimited noise pollution as a necessary byproduct of the jet airplane.

The conflicting pressures brought on by the increased demand for air travel, and the public's concern over noise pollution are forcing us to direct our attention to technological solutions to the noise problem.

Fortunately, the industry that has contributed so much to giving us the highest standard of living in the world has also shown us it is sensitive to the noise problems. They have shown us they can clean up their act, and you have to say that they are.

That is the focus of this hearing this morning. We are not here to debate the merits of restricting air traffic, although that may, someday, be necessary. Today we will focus on noise reduction technology, the current status, as well as the direction of future research in this area and the potential for further alleviation of airport noise problems.

I believe we have assembled the appropriate expert witnesses here today to testify on this important subject, and I look forward to hearing their testimony.

Thank you, Mr. Chairman, for allowing me to make these comments.

The CHAIRMAN. Thank you very much.

Mr. Packard, Ron Packard, from California, do you have any comments this morning?

Mr. PACKARD. Thank you, Mr. Chairman, but I don't have any prepared remarks. I'm just grateful to be down in this beautiful part of the country and to address this very significant issue.

I don't believe there is any part of the country that is unique in terms of air traffic noise problems. I think every section of our country is struggling with this problem, and I'm convinced that the solutions are not going to be in restricting air travel.

I think it's going to be in technology that is going to improve the noise issue at our airports, and so I am looking forward to the witnesses and the testimony and hope that it will lead us to a better understanding of what kind of technology this committee needs to deal with in answer to a very significant problem.

Thank you, sir.

The CHAIRMAN. Thank you, Mr. Packard.

I would just comment that this is a very unusual hearing. We have a member from Florida, a member from California and a member from Kansas. We have the two coasts and the heartland of America represented.

I would say I was a rose between two thorns, but since I am in Mr. Lewis' district, I won't say that. However, the fact of the matter is that aviation interests are very strong in California and in Florida, and for those in this room that may be interested to know, my congressional district in central Kansas, builds in numbers half the airplanes made in the world, built in my hometown of Wichita, KS, and that's both commercial, as well as general aviation aircraft.

So we have an interest in seeing the continuation of a strong aviation industry, but we're also cognizant of the needs over the long term future to build aircraft that can operate consistent with the environment, quietly and acceptably.

I think that can happen. That's the function of this hearing today, to explore, particularly, the research items, the long term

items, going on both in the private sector, as well as Government, to determine whether a new generation of aircraft—and some of these airplanes are already in existence now, and flying at Palm Beach Airport, 757, 767, and others—whether this new generation of aircraft can be operated in a more consistent pattern to reduce noise.

So that's the function of this hearing today. This subcommittee has jurisdiction over all aviation research and development, as well as over some of the regulatory sides of the picture. But our main focus today is how can we build airplanes, how can we design airports, how can we operate an air system with respect to noise that is more acceptable to the public?

So our first witness today is Mr. Gerald Kayten, who is director of the aerodynamics division of the Office of Aeronautics and Space Technology with NASA in Washington. We are delighted to have you here.

I would say this to Mr. Kayten, as well as to all of our witnesses, your entire statements will appear in the record. So, if you would like to summarize in order to get the maximum time for questions, we would surely appreciate that.

You may proceed, Mr. Kayten.

STATEMENT OF GERALD G. KAYTEN, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. KAYTEN. Mr. Chairman and members of the subcommittee.

I am pleased to report to you on NASA's aircraft noise research and the state of noise reduction technology. The overall aeronautics program that we present to you every year for budget authorization covers a large number of research areas requiring many years to complete and so we welcome the opportunity to focus on just one important topic and review the research accomplishments.

NASA's role in this research is to generate advanced noise prediction and noise reduction technology for use by the FAA in establishing noise standards, by the aeronautical industry in developing products that will meet the standards and by the operators in defining flight operational procedures and community control measures for further noise alleviation.

Although dating back actually to the 1940's, our aeronautical noise research became a major effort about 20 years ago when we recognized that jet aircraft noise, if not greatly reduced, could become a serious public nuisance and an obstacle to development of an adequate national air transportation system.

The effort has involved the NASA research centers, the FAA, the engine and airframe manufacturers and a number of university and private research groups, all working in close coordination. It has required large Government and private sector investments, with most of the Federal funding provided through the NASA aeronautics budgets authorized by your committee.

This view graph (figure 1), little cartoon, simply illustrates the variety of noise sources on the typical turbo fan transport. Each of the major engine components, in the upper left, interactions between the engine and the airframe, in the upper right, and even

air flowing over various sections of the airplane itself all contribute to the noise individually and collectively. The research has been directed at understanding, predicting and suppressing all of the various noise sources. It has also included intensive study of the noise propagation from the aircraft to the ground and the perceived effects of the noise on human beings. A long-term objective is to eventually contain within the airport boundaries all aircraft noise which is appreciably greater than the typical ambient noise in the community.

As noise reduction approaches were generated and investigated in our research base, we selected the more promising advances to be integrated by industry teams into experimental engine and aircraft systems and validated in large-scale ground and flight tests.

The manufacturers' participation and the FAA involvement provided assurance that successful results would be applied to actual fleet aircraft, not immediately, of course, but as soon as new rules were promulgated and new production or retrofit became economically feasible.

The new transport aircraft, as Congressman Glickman mentioned, now coming off the production line, feature virtually all of these noise reduction improvements.

In the early turbojet engines the high-velocity jet exhaust, shown at the rear of that upper left, was the major noise source. In the 1960's, low-bypass-ratio turbofan engines were introduced. They offered greater propulsion efficiency than the turbojets and they provided some noise relief, as well: with the core exhaust and the fan exhaust combined, the result was a lower velocity jet exhaust, and therefore, a significant reduction in jet exhaust noise.

An even greater reduction was achieved in the 1970's with the arrival of the higher-bypass-ratio second generation turbofans on the wide-bodied transports. As shown in this view graph (figure 2), however, once the jet exhaust noise, on the left, was reduced, it then became necessary, in order to achieve further improvement, to reduce the fan generated noise, as well as additional reduction of the jet noise.

Laboratory experiments had shown that we could suppress noise by lining the engine ducts and the inlets with materials like honeycomb or bulk absorbent insulators. In 1967, NASA initiated a program in which these research results were applied to acoustically treated nacelles on a Boeing 707 and the Douglas DC-8 and flight tested in 1969.

The design goal, to reduce noise under the approach path by as much as 15 PNdB, which is a considerable reduction, was successfully achieved. The quiet nacelle program proved that acoustic treatment was feasible and effective, and it produced data needed to determine the weight and cost penalties associated with varying degrees of acoustic treatment. Although materials and design have been refined in subsequent years, this quiet nacelle research program provided the basis for the first FAA noise standards in 1969, and for the acoustic treatment in today's new production nacelles and hush kits.

In parallel with the acoustic treatment research, progress was also being made on a number of techniques for reducing fan noise in the engine itself. These included eliminating inlet guide vanes,

reducing the number of fan blade rows, reducing rotational speed, increasing the separation between the rotating and static blades, and improving fan blade aerodynamic design.

In the early 1970's, these concepts were integrated and evaluated in ground tests of an experimental quiet engine, which demonstrated considerable reductions in both approach and take-off noise, and provided an improved data base for future designs. Since many of the narrow-bodied transports still needed engines in the lower-bypass-ratio, JT8D class, NASA contracted with Pratt & Whitney to modify and test the JT8D with a larger diameter, improved single stage fan. We also contracted with Boeing and McDonnell Douglas to install and test these refanned engines on the 727 and DC–9 aircraft. Acoustic treatment was applied to both the engines and the enlarged nacelles.

Ground testing of the engines and the 727 installations, and flight testing of the DC–9 installation were completed in 1975. The results confirmed that with little or no degradation in airplane performance, the refan technologies could provide noise reductions of from 5 to 10 EPNdB, reducing community noise exposure areas by 50 to 80 percent. Pratt and Whitney later incorporated these technologies in their JT8D–200 series production engines, enabling Douglas to launch a new family of narrow-bodied DC–9 transports which, although derived from designs completed years before any noise regulations existed, can actually meet present standards. They also provided increased productivity because they were able to stretch and carry considerably more passengers.

In more recent programs, we have extended the noise reduction principles to even higher bypass ratio engines for use in possible future short take-off and landing aircraft and to small General Aviation turbofan engines.

Now, this view graph indicates that as reductions in the more dominant jet exhaust and fan noise sources are achieved, the additional noise sources, the ones on the right, which were previously secondary, now take on increased importance; the turbine, the engine core, compressor and even the airframe.

Research in all of these areas, including studies on the effects of relatively minor internal engine parameters, has resulted in lesser, but still significant, further noise reductions. Considerable research has also been directed at the effects of atmospheric, terrain and meteorological variations on noise propagation and attenuation, to developing more accurate prediction techniques and to quantifying human response to various noise reduction alternatives.

NASA's Aircraft Noise Prediction Program [ANOPP] has become a valuable and widely used tool for assessment of aircraft and flight operations with respect to noise impact.

Finally, analysis, flight simulation and actual flight testing have been devoted to advanced cockpit information, display and control technologies which, together with improved terminal guidance equipment such as Microwave Landing System, will permit the use of takeoff and landing flight operations further optimized for noise control.

As shown in this final view graph (figure 3), the coordinated noise research has been immensely successful. Today's technology, which is slowly, but steadily, being incorporated into the air carrier

fleet, has made it possible for the FAA to define, and the manufacturers to satisfy, a set of improved standards which reduce perceived aircraft noise by more than twenty decibels relative to the initial jet transports—that's a factor of four—and which reduce community noise exposure by over 90 percent. As the figure indicates, this level of noise is only slightly higher than the ambient noise, that is the noise around the airport with no flights operating.

Now apart from some additional improvement through new operating procedures and possibly land use regulations, further noise reduction on conventional turbofan transports will be slow. It may be achievable, but only after extensive additional research and possibly at the cost of considerably greater performance and economic penalties.

Nevertheless, future growth of the air transportation system and future population growth in the communities and fierce international competition for hundreds of billions of dollars in worldwide transport sales will create continuing pressures for even quieter aircraft and more stringent noise rules. For these reasons, the noise research is continuing at our Langley Research Center, and the present program is directed at a number of new potential problems and opportunities.

We are studying the effects of acoustic loads on the advanced composite materials being developed for future lightweight aircraft structures. We are investigating the influence of noise on boundary layers to make certain that the drag reduction and fuel savings we're pursuing in our laminar flow research will not be negated by sensitivity to acoustic disturbances. We are continuing research to acquire a better understanding of the source noise, cabin noise and acoustic loads associated with high speed propellers, and to generate the data base required for development of comfortable, structurally sound and advanced turboprop aircraft which we are confident will meet existing noise standards. We are continuing the cooperative program with the U.S. helicopter manufacturers and the FAA to develop the capability to predict the noise of new helicopters more accurately and thus to meet future noise standards, which will permit quiet helicopter operation in populous areas. And finally, recognizing that the state of supersonic technology is now a quarter of a century more advanced than that embodied in the Concorde, a portion of our research addresses potential propulsion and aerodynamic advances which could eliminate excessive noise in future supersonic transport aircraft.

In summary, intensive Government and private sector research on the sources, propagation and effects of aircraft noise has resulted in technology which can drastically reduce conventional turbofan aircraft noise. The new technology is now utilized in the latest operational transports and in those currently in production. It can also be applied, to some extent, in modifications to older aircraft.

The growth of the air transportation system and of populations near the airports, and the further development of new vehicle types will require continuing acoustics research to make certain that we stay ahead of the noise problem and that we have appropriate technology available, in advance, to assure that future generations of aircraft will be satisfactorily quiet. As we proceed with

this effort, we hope to maintain the same close Government, industry and community cooperation that has made possible the successful noise reductions we have already achieved.

[The prepared statement of Mr. Kayten follows:]

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PRESENTED BY WITNESS
APRIL 1, 1985

STATEMENT

OF

Gerald G. Kayten

Office of Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Transportation, Aviation
and Materials
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I am pleased to report to you on NASA's aircraft noise research and the state of noise reduction technology as we see it. Although we discuss the overall Aeronautics program with the Subcommittee every year when you consider our budget request, the program covers a broad spectrum of objectives, most of which entail research requiring many years to complete. We therefore welcome the opportunity to focus on a single important topic and review briefly the accomplishments over an extended period of time.

NASA's responsibility in noise research is to generate advanced noise prediction and reduction technology for use by the Federal Aviation Administration (FAA) as a technical basis for establishing noise standards, and for use by the aeronautical industry to assure the development of products that will satisfactorily meet the standards. The data also support the development of flight operational procedures as well as airport and community control measures which further reduce undesirable noise effects.

Our aeronautical noise research, which actually dates back to the 1940's, became a major effort about 20 years ago, shortly after the introduction of jet transports, when it was recognized that unless large noise reductions were achieved, the noise could become a serious public nuisance and an obstacle to the development of an adequate national air transportation system. The effort has been a closely coordinated activity involving the NASA research centers, the FAA, the engine and airframe manufacturers, and a number of university and private research groups. It has required the investment of considerable government and private sector resources, with most of the federal funding provided through the NASA aeronautics budgets authorized

by your Committee and its counterpart in the Senate.

To illustrate the complexity of the problem, Figure 1 shows the variety of noise sources on a typical turbofan transport. Each of the major engine components shown contributes in its own way to the engine noise and requires a unique form of treatment. Additional noise is created by the interactions between the engine and the airframe. And finally, airflow or flow separations over various sections of the airframe can cause enough turbulence so that a very large airplane would generate appreciable noise even if it could fly with no engines at all.

The noise reduction research has been directed at understanding, predicting, and suppressing all of the various noise sources. It has also of necessity included intensive analytical and experimental study of the noise propagation from the aircraft to the ground, as well as the perceived effects of the noise -- and of various noise alleviation measures -- on human beings. The long-term objective is eventually to contain within the boundaries of the airport itself all aircraft noise which is appreciably greater than the typical ambient noise in the community.

The research base has generated a number of noise reduction advances, the more promising of which have been integrated into realistic engine and aircraft experimental systems and validated in large-scale ground and flight tests. As I summarize some of the more significant results, it should be borne in mind that in addition to the years devoted to the research, there is an unavoidable lag between completion of the research and the introduction into the fleet of new aircraft incorporating the resultant improvements. New technology, no matter how attractive, can be applied only as rapidly as new production or retrofit becomes economically feasible. The good news, however, is that the new transport aircraft now coming off the production line feature virtually all of these noise reduction improvements.

In the early turbojet engines the high-velocity jet exhaust, mixing with the surrounding air, was the major noise source. In the 1960's, low-bypass-ratio turbofan engines were introduced. The turbofans offered greater propulsive efficiency than the turbojets, and they provided some noise relief as well. With the help of internal mixers, the engine core and fan exhausts were combined, resulting in a lower velocity jet exhaust and therefore a significant reduction in jet exhaust noise.

An even greater reduction in jet exhaust noise was to be achieved in the 1970's when the higher-bypass-ratio second generation turbofans arrived with the wide-bodied transports. As shown in Figure 2, however, with the reduced jet exhaust noise no longer the primary noise source, further improvements required reduction of the fan-generated noise as well as the jet noise. Laboratory experiments had shown that noise suppression could be accomplished by lining the engine ducts and inlets with materials

which convert the acoustic energy to heat energy -- for example, by resonance in honeycomb cavities or by losses in propagating through bulk absorbent insulators. In 1967, NASA initiated an acoustically treated nacelle program, in which these research results were applied and flight tested in 1969 on a Boeing 707 and a Douglas DC-8. Successfully achieving the design goal of reducing noise under the approach path by as much as 15 PNdB, the Quiet Nacelle program proved that acoustic treatment was feasible and effective. The program also enabled us to determine the weight and cost penalties associated with varying degrees of noise reduction by acoustic treatment.

Although materials and design have been refined in subsequent developments, the technology developed in the Quiet Nacelle research program provided the basis for the first FAA noise standards in 1969 and for the acoustic treatment in today's new production nacelles and "hush kits".

During this period, research was also continuing on a variety of techniques for reducing fan noise in the engine itself. These measures included eliminating inlet guide vanes, reducing the number of fan blade rows, reducing the rotational speed, increasing rotor/stator separation, and improving fan blade aerodynamic design. In the early 1970's, these concepts were integrated and evaluated in ground tests of an experimental engine. The results of this Quiet Engine Program verified the predictions of considerable noise reduction in both approach and takeoff, and provided an improved data base for future designs.

Because a large segment of the air transport fleet was still dependent on engines in the lower-bypass-ratio JT8D class, NASA contracted with Pratt & Whitney to investigate modifications to the JT8D which would replace the two-stage fan with a larger diameter improved single-stage fan. We also contracted with Boeing and McDonnell Douglas to install the refanned engines on the B-727 and DC-9 aircraft, together with the required larger nacelles and structural changes. Acoustic treatment was applied to both the engines and the nacelles. Ground testing of the engines and the B-727 installations, and flight testing of the DC-9 installation, were completed in 1975. The results confirmed that with little or no degradation in airplane performance, the refan technologies could provide noise reductions of from 5 to 10 EPNdB, reducing community noise exposure areas by 50 to 80 percent. These technologies were subsequently incorporated by Pratt and Whitney in their JT8D-200 series production engines, spawning a new family of narrow-bodied DC-9 transports which, although derived from designs completed before any noise standards existed, can actually meet present Stage 3 standards.

In more recent NASA research programs such as the Quiet, Clean, Short-Haul Experimental Engine (QCSEE) program and the Quiet, Clean General Aviation Turbofan (QCGAT) program, we have extended the noise reduction principles to even quieter engines with considerably higher bypass ratios, and to small General Aviation

turbofan engines. In all of these efforts, although noise reduction was the primary motivation, equal attention was paid -- with equal success -- to simultaneous improvements in the cleanliness of engine emissions and in fuel efficiency.

As reductions in the more dominant jet exhaust and fan noise sources were achieved, increased attention was devoted to the additional noise sources which were previously secondary but now took on greater importance -- the turbine, the engine core, the compressor, and even the airframe. Research has continued in all of these areas. For example, the effects on far-field noise of variations in a number of internal engine operating parameters (such as combustor pressure, turbine inlet temperature, and turbine speed) were investigated.

Research has also been directed at the effects of atmospheric, terrain, and meteorological variations on propagation and attenuation. Considerable effort has also been devoted to developing more accurate prediction techniques and to quantifying the benefits of various noise reduction alternatives in terms of human response. NASA's Aircraft Noise Prediction Program (ANOPP) has been made available to the user community and has become a valuable tool for guiding the design and assessment of aircraft and flight operations with respect to noise impact.

Finally, analysis, flight simulation, and actual flight testing have been devoted to advanced cockpit information, display and control technologies which, together with improved terminal guidance equipment such as the Microwave Landing System (MLS), will permit the use of takeoff and landing flight operations specifically optimized for noise control.

As shown in Figure 3, these coordinated government-industry-university efforts have been immensely successful. Today's technology, which is slowly but steadily being incorporated in the air carrier fleet, has made it possible for the FAA to define, and the manufacturers to satisfy, a set of improved standards which reduce aircraft noise by more than 20 decibels in perceived noise relative to the initial jet transports -- a factor of 4 -- and which reduce by over 90 percent community noise exposure for a given number of aircraft operations. As the figure indicates, this level of noise is only slightly higher than the ambient noise in the community itself.

Further noise reduction on conventional turbofan transports may be achievable, but only after extensive additional research and possibly at the cost of considerably greater performance and economic penalties. Nevertheless, we recognize that future growth in the air transportation system, and future population growth in the communities, will create continuing pressure for even quieter aircraft and more stringent noise rules. We also believe that public acceptance will be an important discriminator as the U.S. manufacturers compete for hundreds of billion dollars in worldwide aircraft sales over the next several decades. For

these reasons, we maintain a laboratory dedicated to aircraft noise research at the Langley Research Center in Virginia, where NASA's acoustics activity is largely concentrated. Our present program is directed at a number of new potential problems and opportunities.

- We are studying the effects of acoustic loads on the advanced composite materials which will be used in future aircraft structures to reduce weight. Successful weight reduction will decrease power requirements and hence further reduce noise.

- We are investigating the influence of noise on the stability of the boundary layer on the new airfoil surfaces and systems we are developing to maintain laminar flow which is important for drag reduction, fuel economy, and --again-- decreased power requirements.

- Although the new advanced turboprops are expected to meet existing noise standards, we are directing additional research toward acquiring a better understanding of the source noise, cabin noise, and acoustic loads associated with high-speed propellers, and generating the data base required to support development of comfortable, structurally sound, and environmentally acceptable advanced turboprop aircraft.

- We are engaged in a cooperative activity with the U.S. helicopter manufacturers to develop the capability to meet future noise standards which will permit quiet helicopter operation in close proximity to populous areas. As in the fixed-wing programs, the FAA is also involved in this effort, a major thrust of which is to make it possible to predict the noise of new design helicopters with sufficient accuracy so that development can proceed with confidence that the standards will be met.

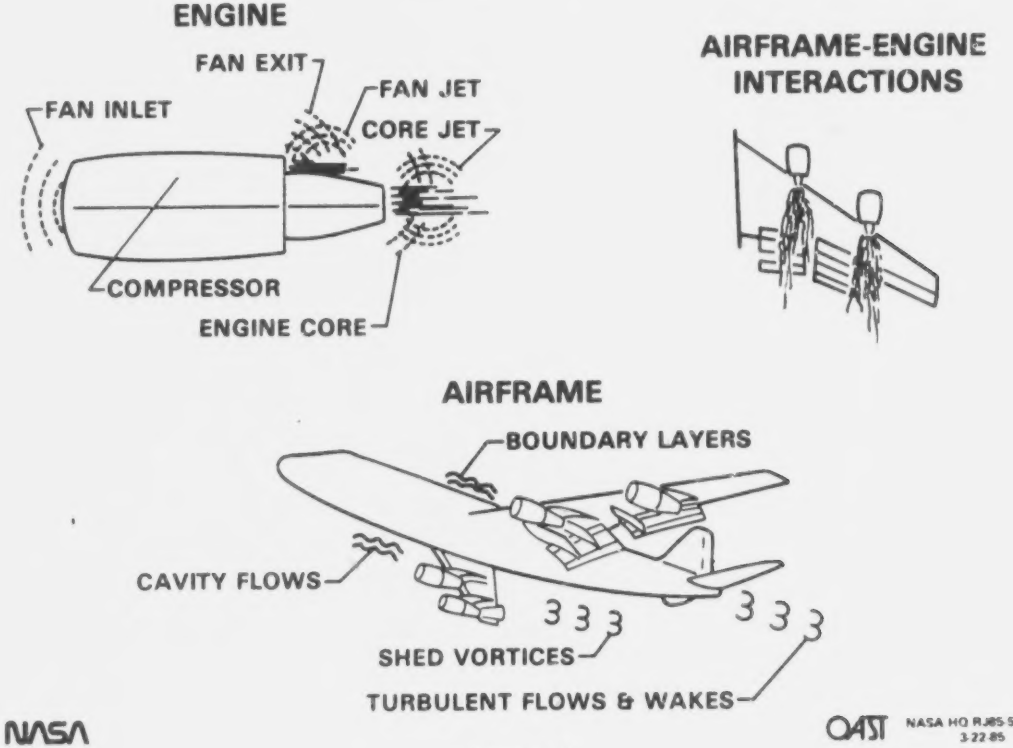
- And finally, recognizing that the state of supersonic technology is now a quarter of a century more advanced than that embodied in the Concorde, a portion of our research addresses potential propulsion and aerodynamic advances which could eliminate excessive noise in future supersonic transport aircraft.

In summary, intensive government and private sector research on the sources, propagation, and effects of aircraft noise has resulted in technology which is effectively alleviating the problem of conventional turbofan aircraft noise as a public nuisance. The new technology is now utilized in the latest operational transports and in those currently in production. It can also be applied to some extent in modifications to older aircraft.

The growth of the air transportation system and of populations

near the airports, and the further development of advanced vehicle types will require continuing acoustics research to make certain that we stay ahead of the noise problem and that we have appropriate technology available -- in advance -- to assure that future generations of aircraft will be satisfactorily quiet.

JET AIRCRAFT NOISE SOURCES



Figures 1

RELATIVE IMPORTANCE OF NOISE SOURCES

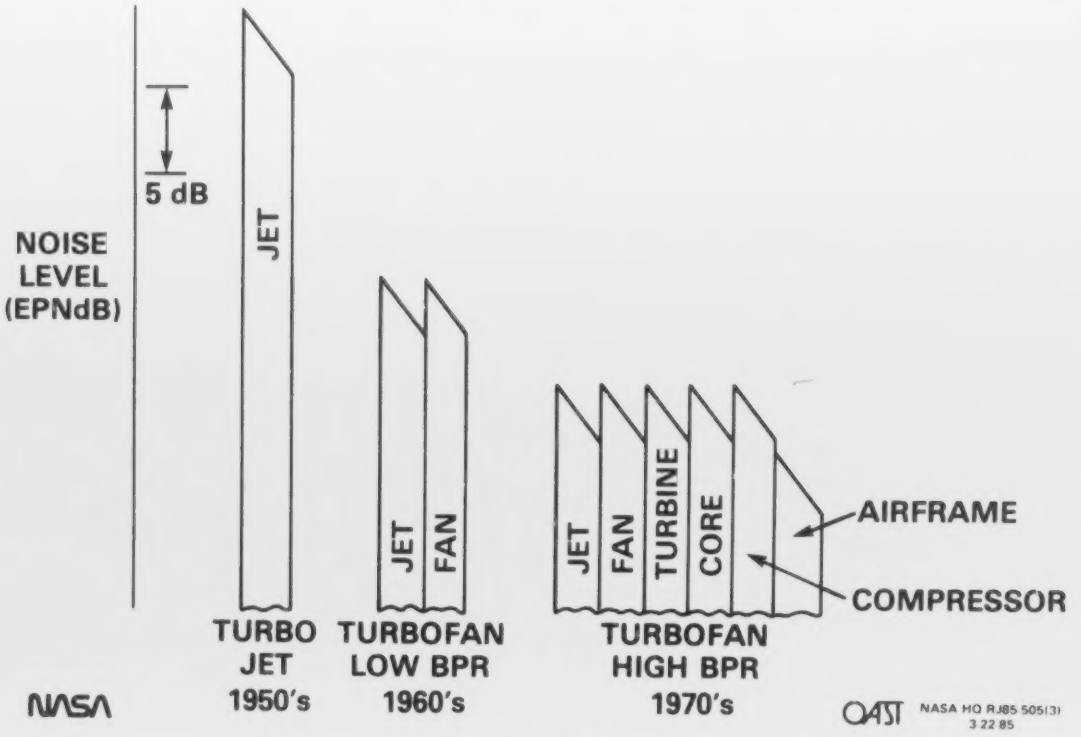
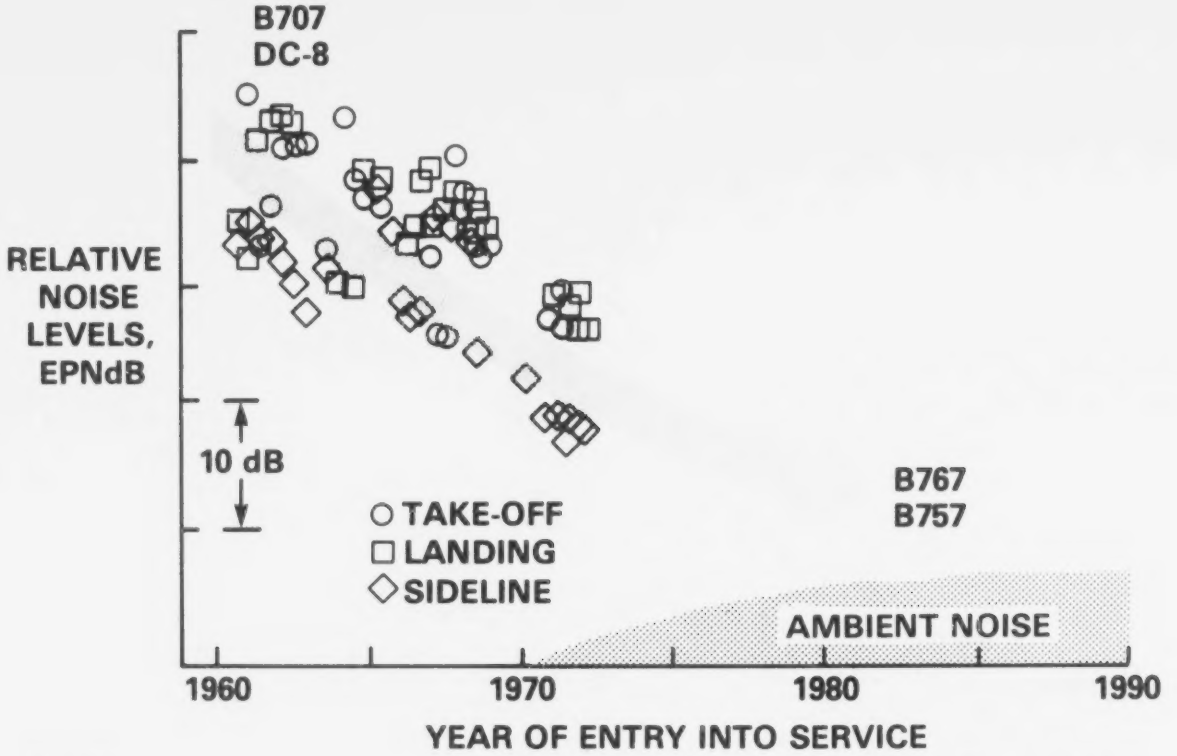


Figure 2

TRANSPORT AIRPLANE NOISE LEVEL TRENDS



NASA

Figure 3

OAST NASA HQ RJ85-504(3) 3-22-85

The CHAIRMAN. Thank you very much, Mr. Kayten.

Let me just ask you a couple of questions.

On page 2 of your testimony, you state that the long-term objective is to eventually contain within the airport boundaries, such as the West Palm Beach Airport, all aircraft noise which is appreciably greater than the typical ambient noise in the community itself.

I assume by that you mean cars and whatever other kind of noise, construction noise.

How realistic do you think, in 10 or 15 years that can be done?

Mr. KAYTEN. I think it's more realistic to say it can be done than it will be done. I cheated a little bit—when I say airport boundaries, a part of that will necessarily involve community action in establishing buffers and land use, and preventing homes from being built right on the runway, for example.

But the technology, itself, does offer some possibilities for getting pretty close to that. With the higher thrust-to-weight engines available, with the improved aerodynamic configurations, and with the active controls technology and automatic information display and things like that, some of the operational procedures become more feasible. But, the most important technology advance, which may or may not take place, would be the introduction of the short takeoff and landing capability. The STOL aircraft that we were working on, powered lift, were really for a degree of congestion that never materialized. But they offer, aside from the ability to go off on side runways, the ability to do steep takeoff and landing maneuvers very safely. Actually, I don't know whether you've seen a demonstration of the QSRA, but that contains all of the noise within the boundaries of the airport by simply operating in a different escalator mode.

The CHAIRMAN. But, realistically, over the next 10 or 15 years, we're going to be operating with some new generation aircraft, 757, 767, the MD-80's series aircraft, but you're still going to be operating with some older generation aircraft, 727's and DC-9's—I think older DC-9's for some period of time.

So what I'm trying to figure out is what can the residents of areas around airports expect, even with the research that NASA is doing and that the private sector may be doing, in terms of the next 10 or 15 years?

Mr. KAYTEN. In the next 10 or 15 years, I think they can expect complete adherence to the present stage 3 regulations, which is good, but not as good as I indicated might be possible.

The CHAIRMAN. Let me ask you this: How much do you spend on noise research at NASA?

Mr. KAYTEN. Right now?

The CHAIRMAN. Yes.

Mr. KAYTEN. For the last several years it's been running slightly under $7 million and in addition to that, about $6 million in some of these systems; at a level between $12 and $13 million a year, 1985 and 1984.

The CHAIRMAN. Has that been a fairly stable number, or has it been going down?

Mr. KAYTEN. It's gone down with respect to the peak years when we ran these quiet engine, quiet nacelle systems programs. Prior to 1970, it was running at something under $1 million a year. It's

been averaging—the R&T base over the past 20 years, average, has been about $7 million a year, for a total of about $135 million. The five major projects that I mentioned have added up to another $140 million a year, so it's a total during that period of some $270 million.

That's quite a bit of money, but right now we're running at about the $12 to $13 million a year level.

The CHAIRMAN. Just to clarify the record, what specifically is at the heart of your acoustics research now; what programs are you doing?

Mr. KAYTEN. In the research base, we have several elements. One is the theoretical aeroacoustics, the development of computational codes and the basic physics. We have a materials and structures effort, which determines not only structural response and sonic fatigue, but cabin noise environment and things like that. We still maintain a small human factors subjective acoustics effort, and we have built up our rotorcraft acoustics theoretical work.

In the systems area, as you know, we have this American Helicopter Society Program, which is absorbing much of, or most of, the systems technology and the rest of it is going into propeller noise determination.

The CHAIRMAN. Thank you. Mr. Lewis?

Mr. LEWIS. Thank you, Mr. Chairman.

Can you explain, Mr. Kayten, what you mean by quantifying the benefits of various noise reduction alternatives in terms of human response?

Mr. KAYTEN. Well, in the early days—it basically is a large statistical and computation exercise.

In the early days, we literally gathered people by the hundreds and sat them under the approach paths with surveys and gave several of them tasks; had some of them playing bridge.

We actually, at one period, when Mr. Wydler, the Congressman from the Long Island district, was a large noise reduction proponent on your committee, flew several hundred people from around the Kennedy Airport area down to our noise laboratory, where we subjected them to many hours of a variety of noise sources and noise reductions. Lately, having established what we think are the degrees of noise that cause annoyance, sleep interruption and so on, efforts have involved demographic determinations, finding the number of people around various airports who are doing what kind of work, where the schools are and so on, and developed some theoretical "People-Decibel" figures which we use in establishing goodness levels.

Mr. LEWIS. You stated that hundreds of billions of dollars are at stake in the private industry.

Why shouldn't the private industry fund the research for noise reduction?

Mr. KAYTEN. Well, this is primarily a Government responsibility in the sense that noise reduction is really done for public benefit. Without Government rules, no industry could afford the investments needed in applying noise research, let alone conducting the research, and without the research that we are talking about, the Government would have no basis for these regulations.

In addition, this $270 million that I mentioned, over a period of 20 years, is an investment with no certainty of success; it's high risk. Even with success assured, there is very little chance that the companies making the investment could appropriate the results to their own economic benefit. There's no product that comes out of it, and very few patents. What comes out is an ability to design airplanes which then the entire industry can use, so there is very little hope of getting benefits. If they do, they come after 20-some years, which is a very poor return on investment strategy.

Now that I have said all that, I must point out, and I don't have a figure, but I assure you that the industry has invested considerably in their own research and in the application of the research results, but not to the level that we're talking about with the Government.

Mr. LEWIS. Does NASA have a cost sharing contract with private industry at the present time?

Mr. KAYTEN. At the present time, I don't believe we do. We have had. We have task sharing. In the case of the Helicopter Society work, the companies match NASA's investment in value in their tasks, which they share. So basically the Government is getting a one-to-one participation.

In the case of the refan program, we had a recoupment clause. Whenever there's an obvious opportunity for a product, we try to protect the Government's interest by getting recoupment, and that has been the case on these refan JT8D's.

Mr. LEWIS. You mentioned rotorcraft. Did you know that this subcommittee has expressed concern about the recent reductions in NASA's rotorcraft research, and in view of these cuts, is your AHS helicopter noise research program adequately funded now?

Mr. KAYTEN. We think so, yes. The original plan was a $10 million NASA investment over a 5 year period, as I say, with matching tasks by the industry, and I think we're about on track. In the first 3 years, fiscal year 1984 was $2 million, 1985 was $1½ million and for 1986 we've given the center a guideline of another $2 million.

So that would be $5½ of the $10 million, in a little more than half of the time, and we are getting the matching industry contributions. Their work is right on schedule and they've been accomplishing some pretty worthwhile tasks.

Mr. LEWIS. Thank you.

The CHAIRMAN. Thank you. Mr. Packard?

Mr. PACKARD. Thank you, Mr. Chairman.

I've been particularly interested in the supersonic progress, and a little bit alarmed at the lack of progress that we've made in that area, or at least I perceive that we have not progressed as fast as I thought several years ago we might when it was first introduced.

Is one of the reasons because of the difficulty of finding a solution to the noise and the sonic boom and some of the environmental concerns?

Mr. KAYTEN. I don't believe so. We're pretty confident that a new supersonic transport could actually exhibit noise levels essentially comparable to subsonic.

The sonic boom would still remain a problem. We can see considerable reductions in the sonic boom, because of the new configura-

tions and the lighter weights, but we don't see an elimination of the "no supersonic flight over land" in the cards yet, which probably doesn't matter because the only thing that would really justify supersonic transport investment would be opening of long over-ocean routes, the Pacific basin and things like that.

But you have to remember that the Concorde engine, the Olympus, is a pure turbojet engine. It was in the same ball park as these early subsonics that we had. The next generation supersonic transport would almost certainly utilize some variable cycle engine, or some equivalent technique and act more like a turbofan in low speed and takeoff flight, and also, a lot of variable inlet and nozzle geometries, which make it amenable to some new noise suppression techniques that have been developed.

You also have to remember that the Concorde weighs about 400,00 pounds. When it operates at Kennedy, it has to offload some 20,000, 23,000 pounds and that reduces the noise from the I think 117 decibels that you get at Dulles, to about a 100 decibels, which is not far from the subsonic.

A new supersonic transport with the improved aerodynamics, materials and propulsion would probably weigh about 100,000 pounds less, so I think the noise would certainly have to be worked, but it would not be an obstacle.

The other environmental effects, the pollution of the upper atmosphere and so on, have all been disproven, I think.

Mr. PACKARD. Do you believe that the U.S. industry will be able to compete in the marketplace in supersonic aircraft in the future?

Mr. KAYTEN. I certainly think that American industry would be involved in supersonic transport development. I think the pattern would more likely be international cooperation than absolute international competition.

Mr. PACKARD. Changing to a different subject, the Federal safety standards permit cutting back on take-off, cutting back on the power, I think, after they reach a thousand feet, or higher.

I may need to be corrected on some of this, but that's my understanding, and some airports have requested permission to cut back at 500 feet.

In your judgment, do you believe that this would compromise safety standards, or do you believe that this could be done without jeopardizing the safety of the passengers?

Mr. KAYTEN. I think I would rather pass on most of that, and perhaps Mr. Wesler could answer it. I think it would depend largely on the airplane, itself, on the situation.

There are variations in these cutback procedures that I do see might make sense. They have more to do, though, with a more rapid climbout, than with a lower altitude cutback, and they require some further improvements in the aircraft than we have right now.

Mr. PACKARD. Let me carry that just one step further: Do you believe that the Government regulations are too stringent or too strict in terms of noise and other environmental concerns on aircraft?

Mr. KAYTEN. Well, since we're trying to keep up with them I would have to say they're just about right.

I think if they were much stricter they would impose penalties that really couldn't be accepted by the technology we have now, and there is no need for them to be any looser because airplanes are meeting them right on the button now.

Mr. PACKARD. Thank you very much.

The CHAIRMAN. Just let me followup on one of Mr. Packard's questions:

You said that, for example, an airplane could enhance its climb-out as one way of reducing noise on the ground, that is, if you climb faster quicker, it would be less noise.

But you said there might need to be some structural or aerodynamic improvements to aircraft. Are you working on this problem at all?

Mr. KAYTEN. Well, in the case of the supersonic research, yes, because the configurations just lend themselves to that, their low wing loading, their low aspect ratio and they have very considerable surplus power.

The CHAIRMAN. How about the subsonic airplane?

Mr. KAYTEN. Well, the subsonics we are not, to my knowledge, working on anything like it, but I think that the industry's improvements in engine thrust-to-weights.

The CHAIRMAN. For example, I was just watching, when I landed, an MD-80 take off from Palm Beach Airport and it's climb-out was much greater than an older generation airplane.

I don't know if it had anything to do with the weight on the plane at the time, but besides having quieter engines, I saw an airplane climb out much faster than I would have seen on an older generation aircraft.

Mr. KAYTEN. I believe the 757 will even do better than that. They are pretty dramatic right now, but I don't know whether they are improved to the point where the regulations could actually be changed.

The CHAIRMAN. We thank you very much for your testimony here today. We really appreciate it.

Mr. KAYTEN. Thank you.

The CHAIRMAN. Our next witness is Mr. John Wesler, who is Director of the Office of Energy and Environment with the Federal Aviation Administration in Washington.

Mr. Wesler, we thank you very much for coming. Your statement is not very long, so you may read it or you may summarize it, whichever is quicker.

Mr. WESLER. With your permission, sir, I will summarize it and ask that the entire statement be entered in the record.

The CHAIRMAN. It will be.

STATEMENT OF JOHN E. WESLER, DIRECTOR, OFFICE OF ENVIRONMENT AND ENERGY, FEDERAL AVIATION ADMINISTRATION, WASHINGTON

Mr. WESLER. Thank you, Mr. Chairman, Mr. Lewis and Mr. Packard. With me this morning, by the way, is Mr. Tom Devine, who is of our legislative staff at headquarters in Washington, DC.

It is a pleasure for us to appear before you this morning, Mr. Chairman, to talk about aviation noise reduction technology. We in the FAA take this issue very seriously.

As you know, our primary job is the development and operation of a safe and efficient system of air transportation for our Nation. And while our primary emphasis should be, and is, placed on the achievement of the first of these objectives—that is, the highest degree of air safety—the second objective is also vitally important to us and receives great attention within the FAA. We have a duty to develop and sustain an efficient system, one which permits aviation to exist and grow without unnecessary constraint, and as Mr. Lewis pointed out in his opening statement, there are conflicting interests in obtaining and operating an efficient system.

As we look to the future needs of the air transportation system for this country, we forecast that aircraft operations will grow over the next decade. Those aircraft operations involve departures and landings at airport runways. At the same time, we do not foresee the number of airport runways growing at anything like the rate of increase in operations that we forecast. As a matter of fact, we see capacity improvements on existing runways being limited as more and more constraints are imposed, and many of these are being imposed for environmental reasons. Therefore, we take the duty of controlling airport noise quite seriously.

Congress first gave the FAA authority to control aircraft noise and sonic boom in 1969, through an amendment to the Federal Aviation Act when it added section 611 to that act. Since that time we have undertaken what we feel to be aggressive measures to protect the public health and welfare as required by statute. Among the factors which the Administrator of the FAA must consider in issuing any such standards and regulations is whether they are technologically practical, and therefore, we interpret this to mean that the state of the art in noise control engineering has been reasonably demonstrated to not only be feasible in terms of engineering, but also will be available for application to the equipment affected. Consequently we are vitally interested in research and development which is underway, both in industry and at NASA in aviation noise control.

Since we first began aviation noise abatement, we have approached this through three parallel paths:

First, and most pertinent to this hearing, we have imposed noise standards on aircraft, to ensure that each is designed and fabricated with noise control as a consideration.

Second, we make every effort to control the pattern of air traffic into and out of the airports so as to minimize the noise impacts on the ground by directing arrivals and departures over nonnoise sensitive areas wherever possible and with respect to the highest degree of air safety. We achieve a great deal of noise control.

The third path which we follow involves airport noise compatibility planning and programs. In this regard, the FAA provides both technical and financial assistance to local airport operators to assist in the planning and design of local noise control programs. We follow this through our so-called part 150; part 150 of the Federal aviation regulations which lays out the policies and procedures and methods for doing airport noise compatibility planning.

Taken together then, these three basic approaches are effective, I believe, in the management and reduction of airport noise problems, though I must say they do not eliminate those problems entirely, and the gains made at great cost in one area may be diminished by noncomplementary actions in another area.

Because of the primary emphasis of this hearing, Mr. Chairman, I will concentrate on the actions we have taken to control noise at the source, that is the plane itself. But I must repeat, and should repeat, that this is only one part of our overall program to control airport noise.

In 1969, we first invoked and first applied noise standards on new civil aircraft designs. As a result of those initial noise standards, the second generation of civil turbojet aircraft, such as the Douglas DC-10 and the Lockheed L-1011, were significantly quieter than the first generation represented by the Boeing 707 and the Douglas DC-8.

The next logical step was the application of those same noise standards to new production aircraft, so that those aircraft coming off the production line—although designed before 1969—were also required, beginning in 1973, to meet those same noise standards. As a result, for example, the Boeing 727's, the 737's, the Douglas DC-9 aircraft manufactured since 1973 have also met the 1969 standard.

The next step was taken in 1976, when we applied those same noise standards as a condition for operation of all larger civil turbojet aircraft. Therefore, beginning this year, January lst, 1985, after an 8-year period of implementation, aircraft were required to meet our initial noise standards as a condition of operation into our airports.

We began this cycle, or I should say, we started again the cycle of regulatory standards in 1977, when we increased the stringency of the noise standards which are applied to new design aircraft.

For simplicity, we have referred to these as stage 1, stage 2, and stage 3 aircraft. Our noise standards basically require meeting noise limits at three locations around an airport runway. These are illustrated very briefly.

Our part 36 noise standards require that noise limits be demonstrated by aircraft at three locations [figure 1]: An approach measurement point underneath the landing path of an aircraft approaching the runway at a distance of 2 thousand meters from the threshold.

The second point is so-called sideline measuring point, a point along a parallel path to the runway centerline at a distance of 450 meters, a point at which the noise is greatest during the take-off operation.

The third is a take-off measurement point at a distance of 6,500 meters from the beginning of take-off roll directly under the take-off path of an aircraft.

The noise levels at these three points are specified in terms of something called the Effective Perceived Noise level, and they gradually increase with gross take-off weight, as is shown here in this chart [figure 2] for the approach noise requirement.

I have shown both the stage 2 noise limit, which is that which was originally imposed in 1969, and the more stringent stage 3 noise limit, which has been imposed since 1977.

We have also plotted on here typical aircraft, beginning with the first generation 707 and DC-8 shown around a 118 to a 120 EPNdB, and to compare those with the more modern aircraft, such as the MD-80 or the DC-9-80, the 757, the 767 and the reengined DC-8, which is designated DC-8-71.

The reduction in approach noise is quite striking, for example, between the DC-8-61 and the DC-8-71. They're looking at something on the order of a 20 decibel reduction, which is one-fourth of the perceived noise level, or reduction of about 75 percent in the perceived loudness of that aircraft.

I should say, also, the vertical lines shown for the 737, the DC-9 and the 727 indicate the effectiveness of the quiet nacelle modifications to those aircraft. Mr. Kayten referred to the quiet nacelle modifications and you can see that the modifications of those older aircraft with the addition of quiet nacelles, provide on the order of 10 decibel reduction in noise level.

Again, that represents about half reduction——

The CHAIRMAN. You don't have the 737-300 series up there anywhere, I don't think.

Mr. WESLER. No, sir; I do not. This was plotted before the 737-300 was certificated; probably Mr. Russell from Boeing will address that for you a little later.

The approach is one of the three noise requirements; sideline is a measure of the total noise, the maximum noise during take-off at full power.

Again, [figure 3] the comparison between stage 2 and the more stringent stage 3 noise limits, and the comparison between the earlier aircraft and the more recent stage 3 aircraft, again, 757's and 767's.

To the left, for your interest, Mr. Glickman, some of the corporate jets are also shown, and they are quite quiet, if I may use that phrase.

Finally, at the third, or take-off location, [figure 4] the drawing is a little more complicated because we have applied technology differently in stage 3 for two engine, 3- and 4-engine aircraft, but again, the comparison between the earlier generation aircraft and the more recent 757, 767, DC-9 Super 80, I think, are quite striking.

One final comparison, [figure 5] and this is very similar to the one that Mr. Kayten showed to you just a few minutes ago.

Here we have compared, using the sideline noise level measurement point, because it does provide a direct measurement of the take-off noise level of the aircraft, the early generation 707, 720, DC-8 technology and the most recent, showing the 1980's technology, where estimated or where measured. Again, the reductions are quite striking, I believe, and show 20- to 25-decibel reduction in the individual noise characteristics of these aircraft.

Along the way, by the way, Mr. Chairman, we have not forgotten the small, general aviation propeller driven aircraft. We have also imposed noise standards on small propeller driven aircraft and supersonic models, too.

So at the present time there are noise standards for almost every type of aircraft, except helicopters and I will address that in just a minute.

Mr. LEWIS. I wonder why you didn't show the Lear on there. You showed the Falcon and the Citation.

Why wasn't Lear shown?

Mr. WESLER. We didn't show all types of aircraft, Mr. Lewis. If we left any out, it was inadvertent. We were just showing representative types.

Mr. LEWIS. I was just thinking there are differences between the Lear and the Citation; there are differences in the DB levels of those engines.

Mr. WESLER. There are certainly differences, sir, and also differences between the early Lear, the 20 series—and the 60 series.

I believe the general aviation manufacturers have done an excellent job in developing and providing to corporations and the industry quieter aircraft. The Citations certainly are an example.

I believe when the Gulfstream goes to a G–4 version with the new Rolls Royce engines, the noise reductions there will be striking there, also.

I should point out that in each of the changes of our noise standards that I have described very briefly here this morning, Mr. Chairman, we have not depended solely on currently available noise technology to meet these standards, but we have, ourselves, along with NASA and the industry, expended a substantial amount of time, effort and resources to create, develop and demonstrate the feasibility of improved noise abatement technology. Without the improved technology more stringent noise standards are meaningless. Clearly it would be useless to require quieter aircraft if their practical design and operation were not possible and the technology were not available to do so.

In the past years, the FAA, itself, has sponsored research and development in aircraft noise control in support of our rule making, most often in cooperation, as already mentioned, with NASA and with industry.

As Mr. Kayten has already explained, the availability of quiet nacelles, which allowed us to go to more stringent standards for new production aircraft and for the new operating rules—that development and availability was a direct result of earlier research by NASA in cooperation with aircraft engine and with airframe industries. The actual demonstration of the airworthiness and noise performance of those modifications was then sponsored by the FAA, forming the basis for our rulemaking.

As Mr. Kayten also mentioned, we are about to propose noise standards for civil helicopters, following several years of developing the bases for such standards, and in conducting our own testing and demonstration of what is available, what is practical, and what limits are reasonable. Many of these have come about because of the joint NASA, FAA and industry noise reduction program. It has been jointly funded by NASA, as has already been mentioned, by the industry and by the FAA and our proposed standards will be based squarely on that.

In summary, Mr. Chairman, I would like to emphasize again that the FAA is vitally concerned about aviation noise and the con-

straints which it can and may place on our national system of air transportation. Aircraft noise levels are decreasing around our airports. Although it's difficult to explain and difficult to convince airport neighbors, aircraft noise levels are coming down, and the reductions, in the case of individual aircraft, are very striking. Current production aircraft are incorporating the best available noise reduction technology and airport noise levels will continue to be decreased as more and more of these new so-called stage 3 aircraft come into use.

Nevertheless, continued research and development in aircraft noise technology is vital if we are to continue to reduce those noise levels. As an agency which promotes improvements in technology and then uses them as the basis for regulatory actions and fulfillment of our statutory duty, we look forward to further advancements in those areas.

That completes my statement, Mr. Chairman. I will be happy to respond to your questions.

[The prepared statement of Mr. Wesler follows:]

STATEMENT OF JOHN E. WESLER, DIRECTOR, OFFICE OF ENVIRONMENT AND ENERGY, FEDERAL AVIATION ADMINISTRATION, BEFORE THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY, SUBCOMMITTEE ON TRANSPORTATION, AVIATION, AND MATERIALS, CONCERNING AIRCRAFT NOISE REDUCTION TECHNOLOGY, WEST PALM BEACH, FLORIDA, APRIL 1, 1985

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to appear before you to discuss aviation noise reduction technology. We in the FAA take this subject very seriously. As you know, our primary job is the development and operation of a safe and efficient system of air transportation for our nation. And, while our primary emphasis must be placed on the achievement of the first of these objectives--the highest degree of air safety--the second objective is also vitally important, and receives great attention within the agency. We have a duty to develop and sustain an efficient system--one which permits aviation to exist and grow without unnecessary constraint.

As we look to the future needs of the air transportation system in the United States, we forecast that aircraft operations will grow by 62 percent from 1984 to 1996. Those aircraft operations involve departures and landings at airport runways; yet we do not foresee the number of airport runways growing by anything like that rate over the same period. As a matter of fact, we see the capacity improvements of the

existing runways being limited as more and more constraints are imposed--many of these constraints caused by noise! Therefore, we take the duty of controlling aviation noise quite seriously.

Congress first gave the FAA authority to control aircraft noise in 1968, through an amendment to the Federal Aviation Act which directed the FAA to establish standards and regulations necessary to control aircraft noise and sonic boom, in order to protect the public health and welfare. Among the factors which the Administrator must consider in issuing any such standards and regulations is whether they are technologically practicable. We interpret this to mean that the state-of-the-art in noise control engineering has been reasonably demonstrated to be not only feasible in terms of engineering, but also will be available for application to the equipment affected. Consequently, we are vitally interested in the research and development underway in aviation noise control.

Since 1968, the FAA has approached aviation noise control along three parallel paths. First, and most pertinent to this hearing, we have imposed noise standards on aircraft, to ensure that each is designed and fabricated with noise control as a consideration. Second, we make every effort to control the pattern of air traffic into and out of airports to

minimize noise impacts on the ground. By directing departures and arrivals over non-noise-sensitive areas wherever possible with respect to the highest level of air safety, we achieve a great deal of noise control. The third path includes airport noise compatibility planning and programs, in which the FAA provides both technical and financial assistance to local airport operators to assist in the planning and design of local noise control programs.

Taken together, the three basic approaches I have outlined are effective in the management and reduction of airport noise problems, though I must say that they do not eliminate those problems entirely, and the gains made at great cost in one area may be diminished by non-complementary actions in other areas. Because of the primary emphasis of this hearing, Mr. Chairman, I will concentrate my remarks on the actions of the FAA to reduce aviation noise at its source--the airplane. But I would like to repeat that source noise control is only one part of the overall program to reduce aviation noise.

In 1969, FAA first imposed noise standards on new civil aircraft designs. As a result of those initial noise standards, second-generation civil turbojet aircraft such as the Douglas DC-10 and the Lockheed L-1011 were significantly quieter than the first generation turbojet aircraft such as the Boeing 707 and Douglas DC-8 models. The next logical step in the application of noise control was the imposition of the same noise standards to new production aircraft in 1973.

After demonstrating that it was technologically practicable to include noise reduction features in older designs of transport category aircraft still in production, FAA extended the noise standards in Part 36 of the Federal Aviation Regulations to include new production airplanes. As a result, Boeing 727 and 737 and Douglas DC-9 aircraft manufactured since 1973 have been required to meet the 1969 noise standards.

The next step was taken in 1976, when the same noise standards were applied to all larger civil turbojet aircraft, including those designed before 1969 and manufactured before 1973. Again, the technological practicability of retrofitting those older aircraft had been demonstrated through the development of "quiet nacelles" and the actual testing of a modified Boeing 707. A period of 8 years was allowed for full compliance with this requirement. A compliance deadline of January 1, 1985, was imposed with earlier interim phased compliance deadlines for U. S. domestic operators.

The cycle of regulatory noise standards was begun again in 1977, when FAA amended Part 36 to increase the stringency of the standards for new aircraft designs such as the Boeing 757 and 767 and the McDonnell-Douglas MD-80. For simplicity, we designated the new, more stringent standards as "Stage 3" noise limits. "Stage 2" noise limits were those initially

adopted in 1969, and "Stage 1" aircraft were those which were unable to meet either of the noise standards. Using this shorthand, only Stage 2 aircraft received aircraft type design approval from 1969 to 1977, and since 1973, only aircraft which meet the Stage 2 standards have been produced. As of January 1, 1985, only aircraft which meet Stage 2 may operate in the United States without an exemption. Since 1977, only Stage 3 aircraft have been approved for new designs.

I have appended to my testimony several charts which illustrate the Part 36 noise standards. The first chart shows the locations of the three noise measurement points required by these standards. The next three charts illustrate the Stage 2 and Stage 3 noise limits at these three locations, and show the measured levels for representative modern aircraft. The fifth chart shows the substantial progress which has been made in reducing aircraft noise.

Along the way, FAA has also imposed noise standards on other types of aircraft, including small propeller-driven models and supersonic models. In all cases, we have worked closely through the International Civil Aviation Organization (ICAO) to seek international harmonization of these standards, in order to facilitate international commerce.

I should point out that, in each change to our noise standards, we have not depended solely on the currently

available noise control technology to meet those standards. We have expended a substantial amount of time, effort, and resources to create, develop, and demonstrate the feasibility of improved noise abatement technology. Without improved available technology, more stringent noise standards are meaningless. Clearly, it would be useless to require quieter aircraft if their practical design and operation were not possible.

In past years, FAA has sponsored research and development in aircraft noise control in support of its rulemaking, most often in cooperation and coordination with the National Aeronautics and Space Administration. For example, the availability of "quiet nacelles" was the direct result of earlier research and development by NASA, in cooperation with the aviation engine and airframe industry. Actual demonstration of the airworthiness and noise performance of those modifications was then sponsored by FAA, forming the basis for rulemaking.

We continue this process today, Mr. Chairman. FAA is about to propose noise standards for civil helicopters, following several years of developing the bases for such standards and conducting our own testing to assure that the procedures are practical and the limits are reasonable. Many of these bases have come from the FAA/NASA/Industry National Rotorcraft Noise Reduction Program, in which NASA and the helicopter

manufacturers have jointly conducted research into the basic mechanisms of rotorcraft noise generation and the technology for controlling and reducing that noise. Our proposed standards will be based on that work.

FAA continues to examine the state-of-the-art in aviation noise control technology to determine if further amendments to our noise standards are appropriate. The next logical steps in regulating aircraft noise would follow the cyclical pattern already established. We are currently examining whether an amendment to Part 36 which would require all new production of turbojet aircraft to meet Stage 3 noise limits after a fixed date may be an appropriate proposal. Currently, with only a few exceptions, commercial and private jets now in production meet the more stringent Stage 3 noise limits. With some improvement in certain sizes of aircraft engines, it may be reasonable to require all new jet aircraft to comply with that standard after some future date. Stage 3 noise standards, in our judgment, represent the best state-of-the-art in noise control now available. Of course we are always ready for new technologies which may arise, or research and development which may show some promise for future technological innovations which can improve aircraft noise control.

Certainly, if all civil aircraft now operating into our airports complied with Stage 3 noise limits, airport noise problems would be greatly reduced. But there are practical

problems associated with such a proposal. There are approximately 2,900 larger commercial airplanes now in use by U. S. air carriers, and over 100 in use by private operators. Of these, approximately 350 were designed for and meet the Stage 3 noise limits. Perhaps 200 more in current use could meet that standard with minimal modifications or weight limitations. This leaves on the order of 2,350 larger aircraft which would have to be retired completely from U. S. service and replaced by new models or re-engined, since the use of "quiet nacelles" or "hush kits" cannot reach Stage 3 noise performance. The only aircraft currently being re-engined are the Douglas DC-8-60 series, which comfortably meet the Stage 3 noise standards with new engines. Many of the existing Stage 2 aircraft are relatively new and have a great deal of useful life left. Consequently, the reasonableness of such a major replacement or re-engining program is obviously one which requires a great deal of study and discussion.

In summary, Mr. Chairman, FAA is vitally concerned about aviation noise and the constraints which it can place on our national system of air transportation. Aircraft noise levels are decreasing around our airports, and the reductions in the noise levels of individual aircraft are striking. Current production aircraft are incorporating the best available noise reduction technology, and airport noise levels will continue

to decrease as more and more of these new aircraft come into use. Nevertheless, continued research and development in aircraft noise technology is vital, if we are to continue to reduce aviation noise. As an agency which promotes improvements in technology and then uses them as the basis for regulatory actions in fulfillment of our statutory duty in the noise control area, we look forward to further advances in aircraft noise reduction.

That completes my prepared statement, Mr. Chairman. At this time, I would be pleased to respond to your questions.

NOISE MEASURING POINTS FOR AIRPLANE TYPE CERTIFICATION

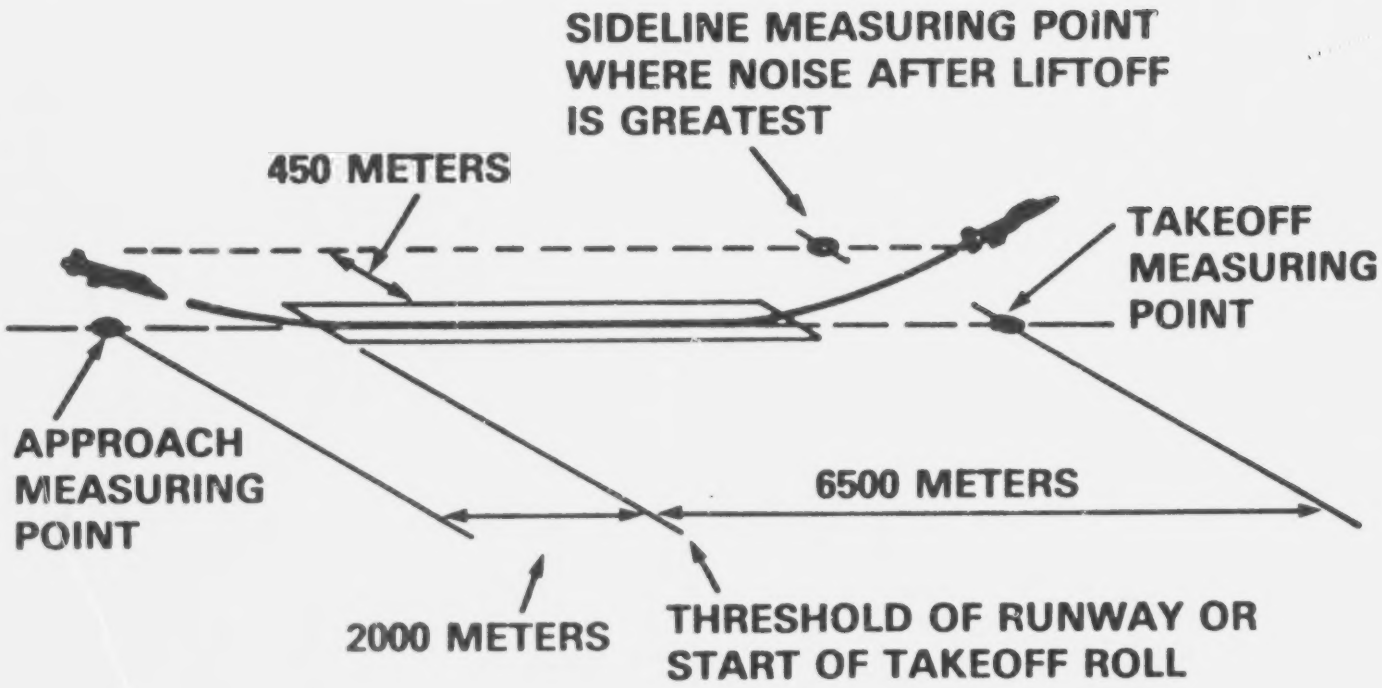


FIGURE 1

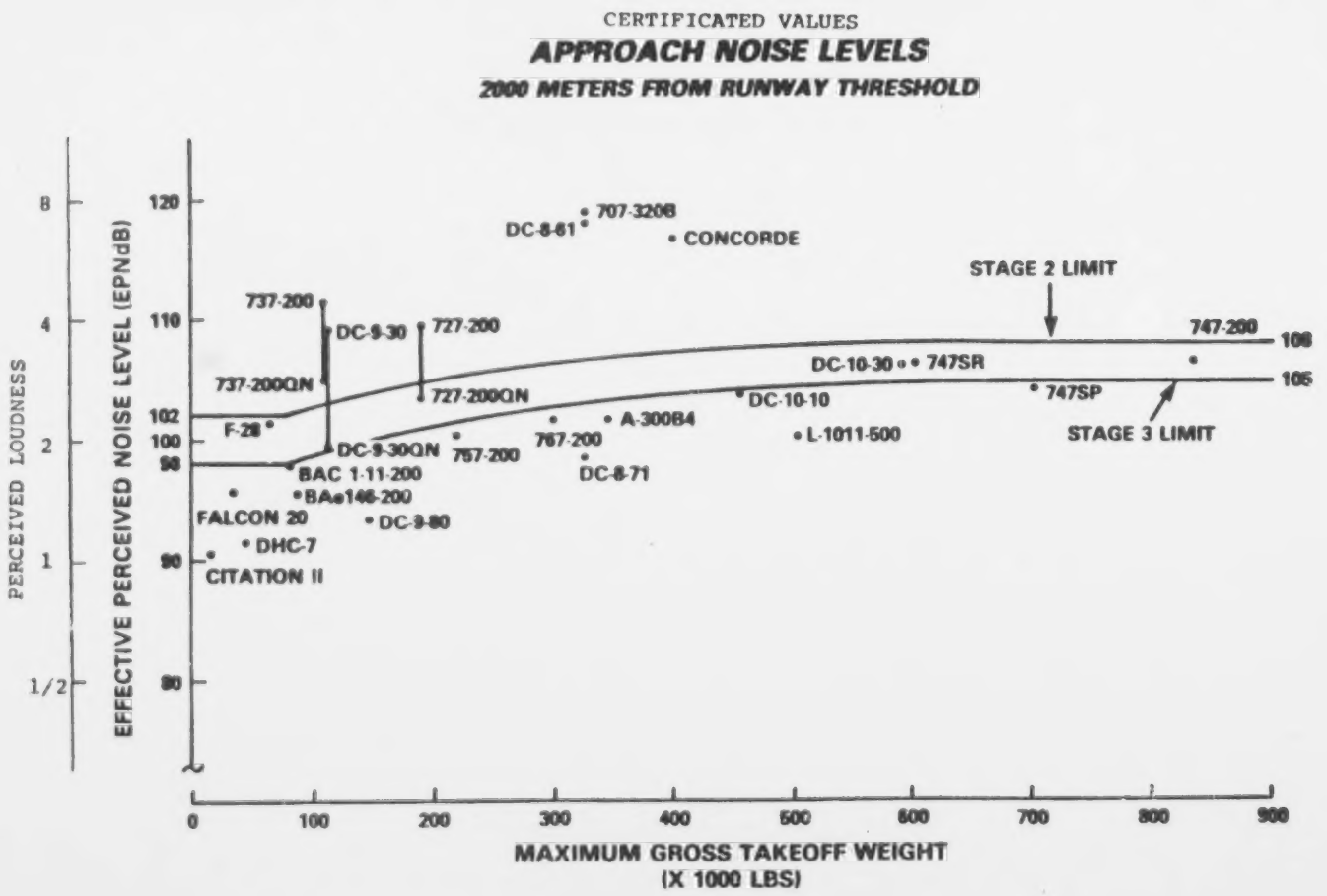

CERTIFICATED VALUES
APPROACH NOISE LEVELS
2000 METERS FROM RUNWAY THRESHOLD
PERCEIVED LOUDNESS
EFFECTIVE PERCEIVED NOISE LEVEL (EPNdB)
8
4
2
1
1/2
120
110
102
100
98
90
80
707-320B
DC-8-61
CONCORDE
STAGE 2 LIMIT
737-200
DC-9-30
727-200
747-200
108
737-200QN
727-200QN
DC-10-30
747SR
747SP
105
F-28
DC-9-30QN
757-200
767-200
A-300B4
DC-10-10
L-1011-500
STAGE 3 LIMIT
BAC 1-11-200
DC-8-71
BAe146-200
FALCON 20
DC-9-80
DHC-7
CITATION II
0
100
200
300
400
500
600
700
800
900
MAXIMUM GROSS TAKEOFF WEIGHT
(X 1000 LBS)

FIGURE 2

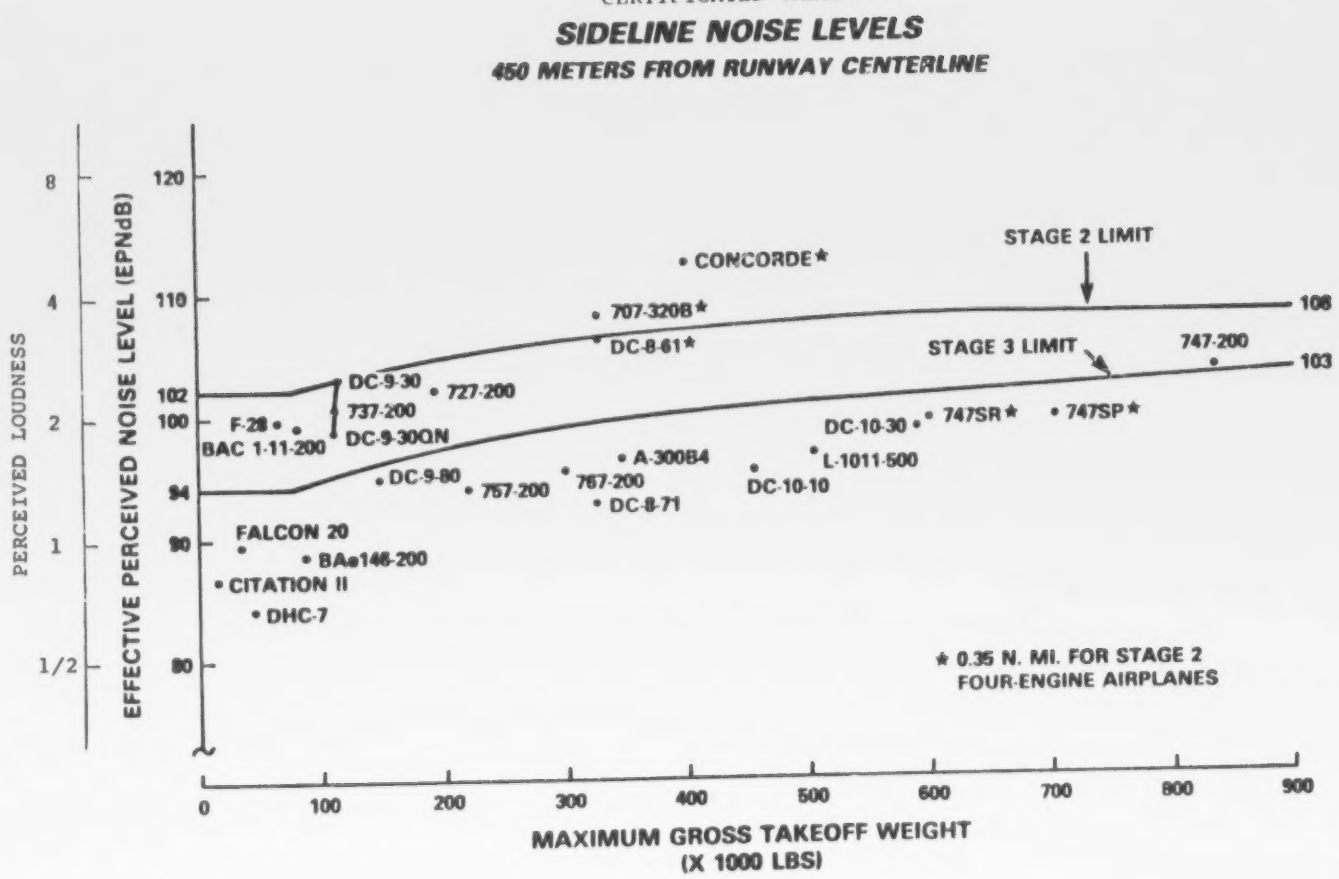

SIDELINE NOISE LEVELS
450 METERS FROM RUNWAY CENTERLINE
PERCEIVED LOUDNESS
EFFECTIVE PERCEIVED NOISE LEVEL (EPNdB)
8
4
2
1
1/2
120
110
102
100
94
90
80
STAGE 2 LIMIT
STAGE 3 LIMIT
106
103
CONCORDE★
707-320B★
DC-8-61★
747-200
DC-9-30
727-200
737-200
DC-9-30QN
F-28
BAC 1-11-200
DC-10-30
747SR★
747SP★
A-300B4
L-1011-500
DC-9-80
767-200
767-200
DC-10-10
DC-8-71
FALCON 20
BAe146-200
CITATION II
DHC-7
★ 0.35 N. MI. FOR STAGE 2
FOUR-ENGINE AIRPLANES
0
100
200
300
400
500
600
700
800
900
MAXIMUM GROSS TAKEOFF WEIGHT
(X 1000 LBS)

FIGURE 3

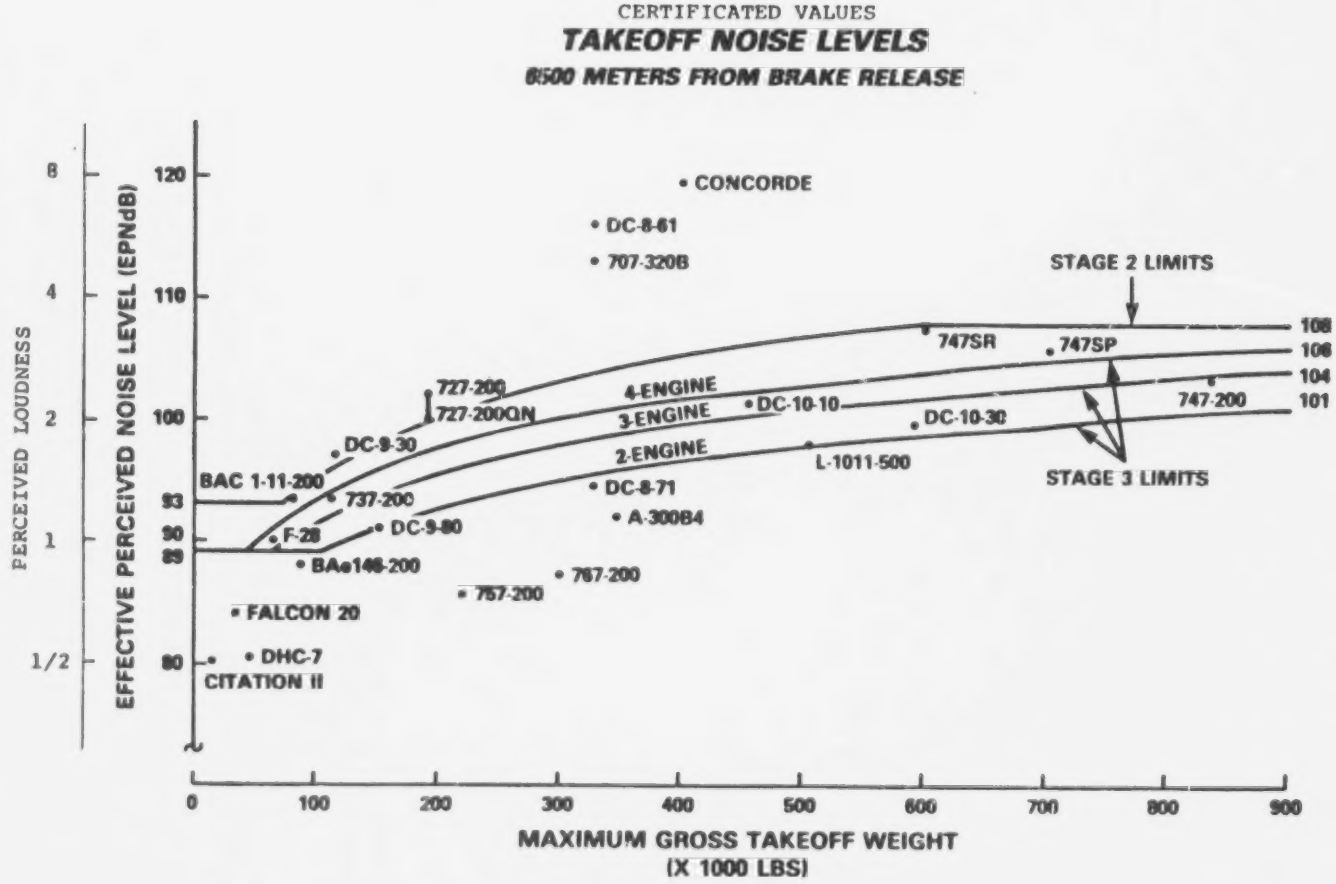

CERTIFICATED VALUES
TAKEOFF NOISE LEVELS
6500 METERS FROM BRAKE RELEASE
PERCEIVED LOUDNESS
EFFECTIVE PERCEIVED NOISE LEVEL (EPNdB)
8
4
2
1
1/2
120
110
100
93
90
89
80
CONCORDE
DC-8-61
707-320B
STAGE 2 LIMITS
747SR
747SP
108
106
104
101
727-200
727-200QN
4-ENGINE
3-ENGINE
2-ENGINE
DC-10-10
DC-10-30
747-200
DC-9-30
BAC 1-11-200
737-200
DC-8-71
L-1011-500
STAGE 3 LIMITS
F-28
DC-9-80
A-300B4
BAe146-200
767-200
757-200
FALCON 20
DHC-7
CITATION II
0
100
200
300
400
500
600
700
800
900
MAXIMUM GROSS TAKEOFF WEIGHT
(X 1000 LBS)

FIGURE 4

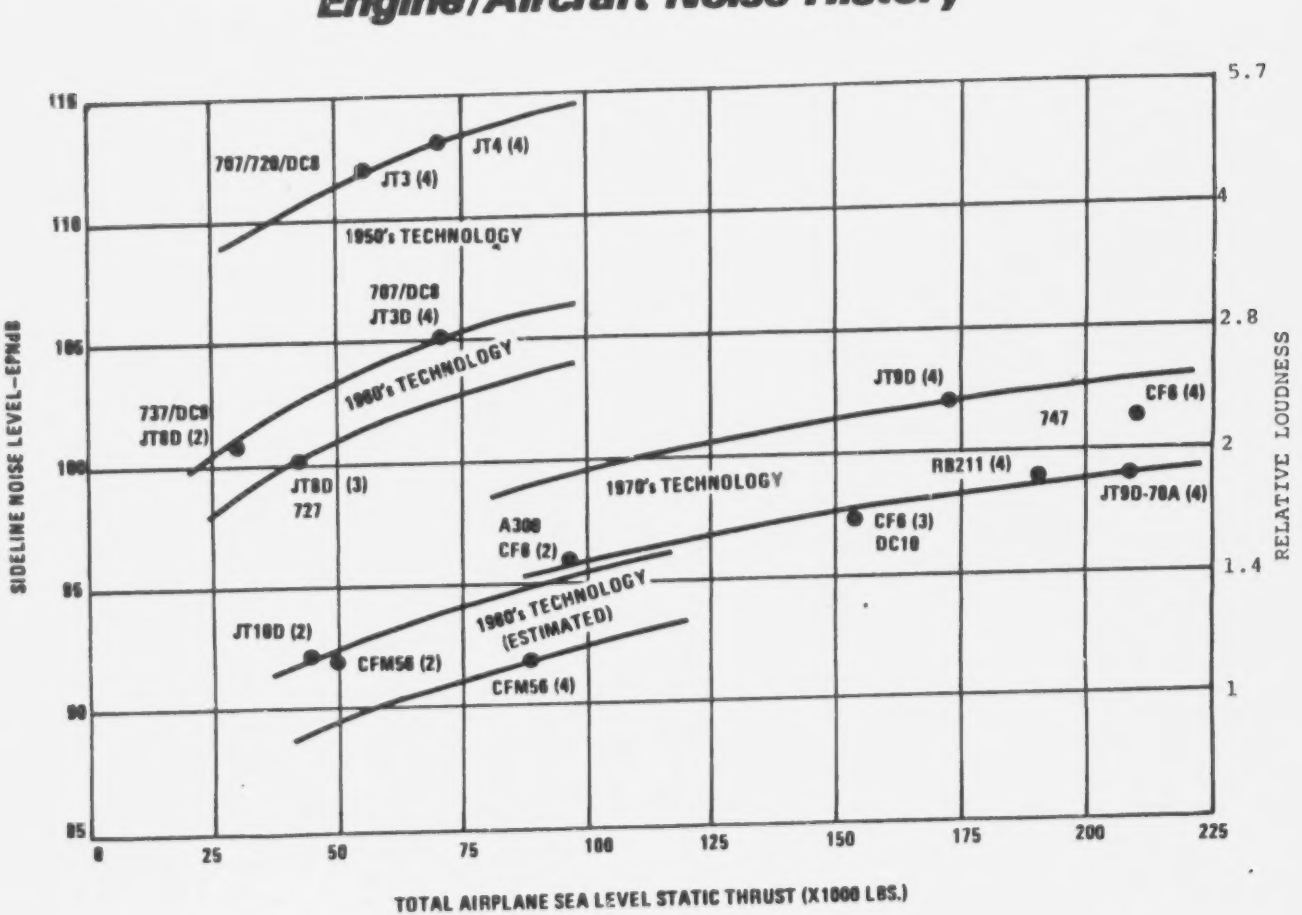

Engine/Aircraft Noise History
SIDELINE NOISE LEVEL–EPNdB
RELATIVE LOUDNESS
TOTAL AIRPLANE SEA LEVEL STATIC THRUST (X1000 LBS.)
707/720/DC8
JT3 (4)
JT4 (4)
1950's TECHNOLOGY
707/DC8
JT3D (4)
1960's TECHNOLOGY
737/DC9
JT8D (2)
JT8D (3)
727
JT9D (4)
747
CF6 (4)
1970's TECHNOLOGY
RB211 (4)
JT9D-70A (4)
A300
CF6 (2)
CF6 (3)
DC10
JT10D (2)
CFM56 (2)
1980's TECHNOLOGY
(ESTIMATED)
CFM56 (4)
115
110
105
100
95
90
85
5.7
4
2.8
2
1.4
1
0
25
50
75
100
125
150
175
200
225

FIGURE 5

The CHAIRMAN. Thank you very much for your excellent testimony.

There were a couple pages in your testimony that you didn't read that I want to talk a little bit about because I think they go to the heart of what the FAA may be doing in the future to get airplanes quieter.

Mr. WESLER. Yes, sir.

The CHAIRMAN. In your testimony, you talk about: "Except for a few exceptions, airplanes being produced now, commercial and private jets, meet the more stringent stage 3 requirements."

So that would be the 757, the 767, the DC-9-80; Airbus?

Mr. WESLER. Airbus, yes, sir; A300, the DC-10, if it were to go back into production, and almost all models of the 747.

The CHAIRMAN. So, new airplanes, no problem then, with stage 3?

Mr. WESLER. In the majority of the cases, that is correct.

The CHAIRMAN. Are there any that have a problem with stage 3?

Mr. WESLER. Yes, sir, there are.

The CHAIRMAN. Which ones?

Mr. WESLER. 737-200, certain models of the 747 and at the present time, the Gulfstream 2 and 3.

The CHAIRMAN. How about the older models of the DC-9, like the DC-30 and the DC-50 series?

Mr. WESLER. They are no longer in production, sir.

The CHAIRMAN. OK, I see. The 737-200 is still in production?

Mr. WESLER. 737-200 is still in production, yes, sir. It may—I would defer to Mr. Russell.

The CHAIRMAN. What is the status of your rule making capacity on existing aircraft meeting stage 3 noise limits?

Mr. WESLER. We are examining that at the present time, sir. We have not come to a recommendation of the agency at this time.

The CHAIRMAN. When do you expect that you will?

Mr. WESLER. I would hope before the end of this year, certainly. I would hope by late summer.

The CHAIRMAN. There I am talking about existing aircraft that are being produced.

Mr. WESLER. Being produced, yes, sir. I understand by that you mean in production.

The CHAIRMAN. Now, let's go to the more serious problem, which is the airplanes which are in the inventory, the three thousand airplanes in the inventory now that do not meet stage 3, and that would have to require—well, as you say, even if you put hush kits or quiet nacelles on them, they still wouldn't meet with stage 3.

Is that correct?

Mr. WESLER. That is correct, sir. They already incorporate that technology.

The CHAIRMAN. So there is no way for them to meet stage 3 unless some of them were totally reengined, like on the DC-8's?

Mr. WESLER. That is basically the only way that they would, by reengining, yes, sir.

The CHAIRMAN. Now it's obvious that if all airplanes met stage 3—what level of decibels is stage 3?

Mr. WESLER. Well, it's difficult, because it does increase with the weight of the aircraft.

The CHAIRMAN. It was in your chart, basically.

Mr. WESLER. Yes, sir.

The CHAIRMAN. OK, if all airplanes met stage 3, what would the people living around the Palm Beach Airport feel; would they feel better or feel worse?

Mr. WESLER. I think they would feel far better, sir. It would not entirely eliminate the noise problems, but I think it would certainly diminish them.

The CHAIRMAN. But to do that with existing airplanes, all the 727's, all the DC-9's that fly—and that probably counts for the majority of actual airplanes that fly there?

Mr. WESLER. Yes, sir. I think I used the figure 2,350 roughly, in the present U.S. fleet.

The CHAIRMAN. So that's about 75 percent of the planes in the U.S. fleet now, that would not meet stage 3?

Mr. WESLER. Yes, sir.

The CHAIRMAN. What you're saying is that it's almost impossible to get those airplanes up to stage 3, unless they are all just reengined?

Mr. WESLER. Basically, that's correct, sir.

The CHAIRMAN. And that would cost billions and billions of dollars.

Mr. WESLER. It is an economic problem, yes, sir.

The CHAIRMAN. The enginemakers might like it, but the manufacturers probably couldn't afford it.

Mr. WESLER. I would think the operators would have a difficult time.

The CHAIRMAN. Yes, and people who buy airplane tickets probably wouldn't like it, either.

Mr. WESLER. Yes, sir.

The CHAIRMAN. So what do you propose to do, then, with respect to the airplanes that are currently flying, anything, that don't meet stage 3?

You've got them meeting stage 2, I guess.

Mr. WESLER. We've gone through the agony of bringing the fleet up to stage 2. We've not been entirely successful with that. There are court cases and other things perhaps we should not get into this morning.

But we have gone through the agony, just recently, of trying to bring the fleet up to stage 2. The bringing to stage 3 will also be a long time, a difficult job.

The CHAIRMAN. The better option, then, is to try to get more of the newer generation airplanes into service so that you can phase out the stage 2 airplanes?

Mr. WESLER. Yes, sir. Some of the stage 2 airplanes still have a long, economic life left in them.

The CHAIRMAN. Are there waivers permitted under any of the stage 2 airplanes, where they don't have to—the older generation planes—meet stage 2?

Mr. WESLER. Yes, sir; the Congress, in passing the Aviation Safety and Noise Abatement Act of 1979, directed us to give waivers for 3 years for something called small community service exemptions.

These are basically the smaller two-engine aircraft with a hundred or fewer seats. There are approximately 550 of those aircraft in the United States fleet at the present time.

The CHAIRMAN. So they would be what, the old DC-9, DC-9-10 series?

Mr. WESLER. Yes, sir, and 15 series and 737-100 series.

The CHAIRMAN. OK so when you say the waiver is in for 3 years——

Mr. WESLER. That's 1988, January 1, 1988.

The CHAIRMAN. So some of those airplanes then fly into the Palm Beach Airport?

Mr. WESLER. Yes, sir, I'm sure they do.

Mr. PACKARD. Mr. Chairman?

The CHAIRMAN. Yes, sure.

Mr. PACKARD. Do you believe that there is a time or that we can set, or the Government can set, a date certain that beyond which violations of stage 3 would not be permitted?

Mr. WESLER. Violations of stage 2, you mean, or an entire stage 3 fleet?

Mr. PACKARD. No, I'm asking if we could move into stage 3 by a certain deadline; is it realistic?

Mr. WESLER. I believe it is realistic, sir. When that time would be, that date certain——

Mr. PACKARD. That would be difficult.

Mr. WESLER. That is the issue.

Mr. PACKARD. I understand. Thank you, Mr. Chairman.

The CHAIRMAN. OK. So you have the 737-100 series, and some of the DC-9 series, have until 1988——

Mr. WESLER. Yes, sir.

The CHAIRMAN [continuing]. To meet the stage 2 requirements?

Mr. WESLER. Yes, sir.

The CHAIRMAN. Beyond that, isn't it true that, in this State, and in one other State, waivers have been granted with respect to some foreign carriers even meeting stage 1 requirements?

Mr. WESLER. Yes, sir, as an amendment to the continuing resolution for fiscal year 1985, the amendment did require us to give waivers at Miami International Airport and at Bangor International Airport in Maine.

The CHAIRMAN. That was just a 1-year waiver?

Mr. WESLER. Maximum of 1 year, yes, sir.

The CHAIRMAN. Was that for a lot of these foreign airplanes that come in, old DC-8's?

Mr. WESLER. It basically addressed the older 4-engine aircraft by whoever operated them. It was contingent upon a number of things, including a firm contract to retrofit, in other words to apply hush kits or quiet nacelles to those aircraft.

The CHAIRMAN. Is it your understanding that that waiver on these older, very noisy planes is going to be extended for another year?

Mr. WESLER. Not if we can help it, sir.

The CHAIRMAN. It is your recommendation that it not be extended another year?

Mr. WESLER. Yes, sir.

The CHAIRMAN. Just one quick question on the issue of safety versus noise:

I assume this is a fair statement, that if at anytime the operator of an aircraft feels that noise abatement runs in conflict with the safe operation of the airplane, that the FAA is opting for the safe operation of the airplane?

Mr. WESLER. Clearly, sir; safety is our maximum priority.

The CHAIRMAN. You were talking about the issue of engine cutbacks at a certain number of feet. Mr. Packard mentioned that, reducing that from a thousand to 500 feet.

I wonder if you might comment on the status of that, as well as generically, the issue of operational reductions of noise and how you fit in vis-a-vie the airport operators.

Mr. WESLER. There are two different issues there:

First of all, it is the FAA's policy that there should be no configuration change below a thousand feet during the take-off of an aircraft with passengers on board; in other words, in revenue service. By configuration change, we basically do not mean gear up or changing some of the flaps, but major change to power settings.

However, particularly in Orange County, in southern California, the issue has been raised about reducing noise at a lesser altitude, particularly 500 feet. The only aircraft that is permitted to do this by the FAA now is the MD-80, which has electronic equipment called the automatic reserve thrust system, which will automatically detect the failure of one of the two engines on that aircraft, and automatically apply full power on the second, or remaining, engine of that aircraft, without any intervention by the pilot himself. That is the only authorized cutback at the present time below a 1,000 feet, only at Orange County, and there are four operators currently that have that authority.

Mr. PACKARD. Mr. Chairman, would you yield on that point, sir, so that I can pursue that a little bit?

The CHAIRMAN. Sure, I would be glad to.

Mr. PACKARD. If other aircraft put in similar technology capable of performing the same kind of safety feature, would that then increase, or expand, that option to other aircraft?

Mr. WESLER. Assuming that they did it in a safe fashion, yes, sir.

Mr. PACKARD. So technology can, perhaps, permit additional aircraft from remaining at full power above or up to the 1,000 foot level?

Mr. WESLER. Yes, sir, and let me, if I may, sir, answer the second part of Mr. Chairman's question.

Mr. PACKARD. Yes, go ahead.

Mr. WESLER. The cutback of the power at a 1,000 feet, 1,500 feet, 500 feet, is most advantageous to the so-called stage 2 aircraft; in other words, the JT3D and the JT8D——

The CHAIRMAN. 727-200 series.

Mr. WESLER. The 727-200. As we go to the so-called high-bypass engines that are on the 757, the 767 and in some respect, the MD-80, the cutback of power does not provide that much noise reduction, and in many instances, it is better for those aircraft to continue to climb out at takeoff or maximum climb power.

From a noise on the ground aspect, the cutback really does not make sense for those aircraft. We are really only talking about the so-called stage 2 aircraft, the older generation.

The CHAIRMAN. Well, I'm sure I speak for everybody on this committe, that while noise is a problem, I don't think that there is a person in any regulatory side, or on the legislative side, that wants to see you do anything that will jeopardize safe climb outs, notwithstanding people that have problems with noise on the ground.

Mr. WESLER. Sir, I'm the FAA's environmental advocate, but when I'm flying in the back, I like that, too.

The CHAIRMAN. One final question:

How much authority does an airport operator have on the issue of noise; that is, the operator of West Palm Beach Airport, can he do anything with respect to noise that is, perhaps, showing some discretion?

Mr. WESLER. Yes, sir. We view airport noise compatability planning as a shared responsibility. It is a shared responsibility among the FAA and the Federal Government and the airport proprietor.

In the long run, it is the airport proprietor that stands responsible for any damages, any law suits, any litigation over noise that may arise from the operation of his airport. He obviously has authority to control noise. Our role is that of the Federal overseer to see that anything he does is nondiscriminatory, is not an undue burden on interstate or foreign commerce, and in fact, does provide some noise abatement and is not cosmetic, for example.

The CHAIRMAN. Have you had any particular problems with any airports in this country with respect to airport operators who might have been using that power perhaps too aggressively, or not as aggressively as they should?

Mr. WESLER. There are questions raised quite often, Mr. Chairman, at individual airports, whether it be Orange County or some others.

I wouldn't say problems, sir. There are always issues being raised.

The CHAIRMAN. Of course, this may depend on State law, whether an airport operator would have the authority to condemn property around an airport, but would the FAA have any authority in those cases?

Let's say that the West Palm Beach Airport could, under Florida law, engage in rather dramatic condemnation procedures, could you have the authority, as the FAA, to come in and intervene in that kind of proceeding?

Mr. WESLER. No, sir, I don't believe so. I don't believe the Federal Government has any authority, or should have any authority over local land use, zoning land use controls of that type.

The CHAIRMAN. The question as to when airports can stop receiving traffic in the evening and start receiving traffic in the morning, is that within the jurisdiction of the local airport operator?

Mr. WESLER. Yes, sir, it is. As I mentioned, he may so long as it is applied in a nondiscriminatory fashion and it does not become an undue burden on interstate or foreign commerce.

That's a very difficult issue. When does a nighttime restriction, for example, become an undue burden? If every large airport across the country were to impose a curfew, I think that would become,

very quickly, an undue burden on interstate or foreign commerce. If individual airports do this, to a lesser degree, it's a matter of balance. It's difficult to answer.

Mr. CHAIRMAN. Thank you. Mr. Lewis?

Mr. LEWIS. Thank you, Mr. Chairman.

In your presentation you showed us several graphs on your approach, takeoff and landing. What does perceived noise level mean; what does that really mean?

Mr. WESLER. That is a representation of the way in which people respond, or react, to aircraft noise, the degree to which they find it annoying. Basically it takes into account the duration of the noise; it takes into account the way in which the average person hears the high frequency and the low frequency. It's a complex mathematical calculation, based on actual noise measurements.

Mr. LEWIS. Mr. Packard asked you a question about when you felt that maybe stage 3 aircraft, most of the aircraft in the commercial fleet, would meet stage 3, and you didn't really have a good answer for that, and you thought it was coming off the wall.

Now, I'm really concerned that you feel that an aircraft has up to 30 years of actual life, but yet we have the 737-200, which does not meet stage 3, which is still in production; we're talking about another three decades out here before we get this thing under control.

Why can't we come up with a reasonable time; we say that by January 1, 1985, we must meet stage 2, isn't that correct?

Mr. WESLER. That's correct.

Mr. LEWIS. Why don't we say a reasonable number, like by 1990 or 1995, or something like that, that all the noise requirements must be met for stage 3?

Mr. WESLER. To give you a very bureaucratic answer, sir, we are examining that right now, and we hope to provide a proposal.

Mr. LEWIS. You are just starting to examine it?

Mr. WESLER. No, sir, we have been for several years. We have basically been trying to get through the stage 1 phase out, if you will, which began the first of this year.

Mr. PACKARD. Would the gentleman yield briefly?

Mr. LEWIS. Certainly.

Mr. PACKARD. Is it a matter of money to increase the research in that area; is it a matter of commitment? What is the deterrent from keeping us from setting a date certain to try to reach that goal?

Mr. WESLER. I think it's the number of stage 2 aircraft that are in service at the present time, Mr. Packard. There is a large fleet out there that, as Mr. Chairman has mentioned, cannot be modified. They would have to be replaced.

The CHAIRMAN. Or reengined?

Mr. WESLER. Or reengined, so it would become an economic, as well as a physical, aspect; just replacing that many aircraft will take time.

Mr. PACKARD. Well, it would appear to me, still in line with what Mr. Lewis is pursuing, that with all that information, we still ought to be able to set some date that we can work toward.

I think goals and objectives and a date certain has its merit.

Mr. LEWIS. I guess what concerns me, primarily, is we still allow production of aircraft that in no way can meet the stage 3.

What we are really saying is we're going to have a good percentage, and 737 is a high percentage production aircraft for the fleet today—we are saying we are allowing aircraft that cannot meet stage 3 but will last for at least another three decades.

I'm just wondering why it's taking so long even to come up with some preliminary type of dates.

Mr. WESLER. It's a difficult question, sir, that we have not faced up entirely to, as yet; we are, at the present time.

Mr. LEWIS. Maybe we should have some of the bureaucrats that have to come up with this answer answer the telephones from the people down here that hear these airplanes takeoff.

Mr. WESLER. Sir, I wish you would sit in my office and answer some of the telephone calls I get every day.

Mr. LEWIS. I'd like to know if the FAA feels that airport noise in general is increasing or decreasing?

Mr. WESLER. I believe it's decreasing, sir. Even though the level of operations is increasing and increasing rather dramatically, the noise levels of the individual aircraft are decreasing.

As a consequence, we feel that since we initially imposed the stage 2 compliance rule in 1976, as of this year, we feel that the noise exposure around airports has reduced on the order of 35 percent

Mr. LEWIS. Let me ask you a sort of technical question:

I fly in and out of this airport regularly. I am a pilot and I fly planes in and out of here, and I get very concerned and the chairman alluded to this, as to the safety factor in looking at fanning and things of that nature, depending upon the loads of the aircraft, and here in Florida, and particularly in this area, we are highly susceptible to windshear.

What kind of safety requirements, or standards or thresholds, are placed in order to ensure that we do not place aircraft passengers in jeopardy?

Mr. WESLER. With all due respect, you're getting out of my field, Mr. Lewis. I'm not sure that I can properly answer that.

That is one of the reasons that we have held to the 1,000 foot altitude minimum for configuration change.

Certainly windshears, or microbursts, or whatever you wish to call them, are possible even above 1,000 feet, although they are most predominant below 1,000 feet. That is one of the reasons we have held to the 1,000-foot minimum for cutback, or for configuration changes, except where it has been demonstrated that there is automatic equipment that will detect that sort of thing.

Mr. LEWIS. Could you have someone from the FAA respond to that question?

Mr. DEVINE. Mr. Lewis, I believe the people that are going to testify before the committee tomorrow on the CID hearing are the people who are in charge of the windshear program, so perhaps tomorrow they could respond to your question.

Mr. LEWIS. All right; thank you, Mr. Chairman.

The CHAIRMAN. Before I yield to Mr. Packard, Mr. Lewis, the 737-200 series is substantially manufactured in my district.

There are approximately 4,000 or 5,000 people at Boeing Military Airplane Co. where that is done that are, of course, making those planes on a daily basis.

Now that is not enough reason why you wouldn't want to get those planes quieter, but this is now the fastest selling airplane in the world, the 737, and it's a complicated problem, I guess, is a bureaucratic response to a bureaucratic response.

Does the 737-300 series meet the stage 3 requirements?

Mr. WESLER. Yes, sir, it does.

The CHAIRMAN. OK.

Mr. LEWIS. Can they switch over to the 300, Mr. Chairman?

The CHAIRMAN. Well, the idea is to try to sell more of the 300's as time goes on.

Mr. WESLER. I would invite you to ask Mr. Russell when he comes up.

The CHAIRMAN. I'm sure we will. Mr. Packard?

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. Wesler, are we finding any problem with international civil aeronautics organizations in terms of a cooperative effort to meet noise abatement efforts from foreign aircraft coming into the country?

Mr. WESLER. No, sir. Obviously when we impose some sort of a limit which may stop the operation of an airplane, that will impose some controversy, particularly when it's perceived as unilateral action by the United States.

We do attempt to "harmonize," to use the international word, or coordinate international standards as fully as possible through the International Civil Aviation Organization. The ICAO works through a series of technical committees and technical panels. I am the U.S. representative on the ICAO committee on aviation environmental protection. So I work continuously with my counterparts in other major countries around the world to make certain that our standards and their standards are compatible and that they are coordinated and work together, and that there is not an unreasonable imbalance, either on foreign trade between our country and other countries or on operating requirements.

Mr. PACKARD. Are there ever waivers granted by the FAA in terms of foreign aircraft coming in that exceed our noise standards?

Mr. WESLER. Yes, sir and we have granted a couple of waivers, particularly where the national interest was concerned.

An example comes to mind of Iceland Air. We have granted them a waiver of the January 1, 1985, deadline for approximately 8 months.

Mr. PACKARD. I see.

Private aircraft, private jets, corporate jets, often receive the most criticism of noise problems, and yet, in your testimony you indicated that we have made perhaps our very best advances in that area.

I have to assume that that's in the new aircraft.

Mr. WESLER. Yes, sir.

Mr. PACKARD. Some of the older ones still, perhaps, are very noisy. I think the noise of private jets is accentuated because a lot of times they do not just land at the commercial airports. They

land at our little private airports, also, where they stand out in vast contrast to our general aviation aircraft.

Is there a different set of standards, or should there be a different set of standards at a noncommercial airport for private jets, in comparison to those same jets landing at a commercial airport?

Mr. WESLER. A bureaucratic answer, sir; the answer is yes and no. From a Federal viewpoint, the answer is there should not be a difference. The same level of technology should be applied across the spectrum of aircraft and we have attempted to do that.

From a local point of view where residences may exist closer to the runways—where the airport extent, itself, may be smaller—it may be justified to have more stringent, tighter, noise standards at smaller airports.

I'm sorry, sir, the answer is yes and no.

Mr. PACKARD. Thank you.

The deregulation, has it enhanced or has it reduced our noise abatement efforts, or has it not had any effect, at all?

Mr. WESLER. Well, I think it has emphasized the need for noise abatement efforts, as more and more new airlines have come into being, as they have gone to more and more places, I think the issue of noise and noise problems has been emphasized.

Mr. PACKARD. The hub and spoke system—has that created any unique sets of problems that we did not before have?

Mr. WESLER. It has increased the numbers of operations at many airports, at Newark, at Baltimore-Washington, near where I live, and at other airports, where hubs have been created where they did not exist before.

The CHAIRMAN. Would the gentleman, yield on that point?

It has also created an additional and continuing market for older airplanes; as the People Expresses, and Air Floridas and others get in there, they don't buy 757's.

They buy used 727-100 series airplanes and other planes that don't meet stage 3, certainly, and some of them don't meet stage 2.

Mr. WESLER. You're quite right, Mr. Chairman.

Mr. PACKARD. That leads me to my next question:

What do we do with the older aircraft that we normally would like to phase out and many of our companies do phase them out on a routine basis?

What happens to those aircraft that normally would not meet stage 2 requirements?

Mr. WESLER. As the Chairman has already mentioned, they do go to new entrants. Many of them go overseas to South America, Africa and to the lesser developed countries. Many are exported and many find themselves in use by new entrants, the newer airlines that cannot afford new airplanes.

Mr. PACKARD. One last question, Mr. Chairman, if I may and that is:

I sat on the aviation subcommittee on public works when we phased out and sunsetted CAB; has that phase out and has FAA and other agencies within the Department of Transportation that have assumed the duties of the CAB, has that created any unusual or unique problems in terms of your responsibilities with, not only air safety but with noise abatement?

Mr. WESLER. No, sir, I cannot say that it has. Much of that has gone over to the Department of Transportation. I think I probably talk with the people in the office of the Secretary of Transportation more than I did with CAB, because of proximity, only. I don't believe, sir, that it has affected my responsibilities or my duties.

Mr. PACKARD. Thank you, Mr. Chairman.

The CHAIRMAN. I would just make a couple points. One of the things is that American manufacturers built such a quality product that the products last a lot longer than what we would like them to last.

That's not a fair statement. They've lasted a lot longer than I think anybody anticipated, and therefore, it is, in some ways, impinging upon a new generation of aircraft coming into play, because the older airplanes, the Boeings, McDonnell Douglas aircraft are just so good that they could last another 20, 25 years.

One question to follow up on what Mr. Lewis asked you, had things been getting better in terms of noise reduction at airports, and your answer is yes.

Would that also be true in the next 5 years; people living at the Palm Beach Airport, if somebody were to ask you if it was going to get quieter there, how would you respond?

Mr. WESLER. I believe it is, sir. I believe the rate of decrease will not be as rapid as it has been. Part of the rate of decrease has been caused by our 1985 deadline, by phasing out the older, stage 1 aircraft and requiring only stage 2.

As the newer stage 3 aircraft come into the fleets and replace the stage 2 aircraft, the improvements will continue, but I think at a lesser rate.

The CHAIRMAN. And that would be true at Miami Airport, Fort Lauderdale or any of the other airports in the country?

Mr. WESLER. Any other airport, yes, sir.

Mr. PACKARD. Mr. Chairman?

The CHAIRMAN. Yes.

Mr. PACKARD. Would you yield on that point and let me carry it a little bit further? Are we, or is it realistic, or even fair, to prioritize some of our airports in terms of noise problems and its effects upon the residential areas?

Orange County is a case in point, where you've got some unique communities that are being severely impacted by takeoff, and obviously we have that kind of problem here.

There must be airports in this country that feel the impact much greater than other airports. Are there ways that we can impose a different set of standards, or increase the efforts or step up the timetables in those airports where we have the most concern?

Mr. WESLER. That is a very difficult thing to do, Mr. Packard. Our system of air transportation is, indeed, a national system. Aircraft don't go just to one airport. They go to many airports as they follow their route structure. So an attempt to impose restrictions at one airport more stringently than at the other can impact the system. It's a very difficult thing to achieve.

Mr. PACKARD. I appreciate that.

Mr. WESLER. Philosophically, I guess, it sounds good, but practically, it is difficult.

Mr. PACKARD. I can understand.

The CHAIRMAN. I want to thank you for excellent testimony, Mr. Wesler. We appreciate it very much.

Mr. WESLER. Thank you, Mr. Chairman, and thank you, members.

The CHAIRMAN. Our last group is a panel of witnesses, and we would like all of the panel to come up here at one time, if possible.

We have four witnesses. We have Dr. Perrey Goldberg with Pratt & Whitney. He is chief of the Acoustics Engineering and Nacelle Aerodynamics department; Mr. Richard Russell who is chief engineer of Noise Technology at the Boeing Commercial Airplane Co.; Mr. Kevin Cooper who is director of Operations Service Support at Eastern Air Lines, and Mr. Kirk Irwin, Vice-President of Engineering & Development at Tracor Corp., Goleta, California.

If you are all here, we would ask you to come forward and sit down, and I would ask you to testify in that order; Mr. Goldberg, Mr. Russell, Mr. Cooper, and Mr. Irwin.

We will hold questions until such time as you have all completed your statements, so we will just go in that order.

I will tell you, if you wish to read your statements, that's fine, if you think that is the quickest way of doing it.

Sometimes when I tell people that you can summarize, the summary takes twice as long as reading the statement.

So, if you can summarize faster than reading your statement, fine; otherwise, just go ahead and read your statement.

You may go ahead, Dr. Goldberg.

STATEMENT OF DR. PERREY GOLDBERG, CHIEF, ACOUSTICS ENGINEERING AND NACELLE AERODYNAMICS, PRATT & WHITNEY AIRCRAFT

Dr. GOLDBERG. Mr. Chairman and members of the subcommittee.

I thank you for the opportunity to appear before you today to discuss the status of jet engine noise reduction technology.

As chief of acoustics engineering and nacelle aerodynamics at Pratt & Whitney, my responsibilities encompass all of our research and development activities directed at reducing the noise of gas turbine engines.

Pratt & Whitney is the world's leading producer of jet engines for commercial and military aircraft. Our company also has been involved in producing rocket engines for the Nation's space program.

Pratt & Whitney is dedicated to the development of quieter aircraft engines. For approximately 25 years, we have played a major role in the aircraft industry's efforts to reduce noise. Last year we spent more than $5 million on programs directed at developing noise reduction technology.

Today's modern high-bypass ratio engines are significantly quieter than the first jet engines that entered commercial service in the last 1950's. At high-power takeoff conditions these reductions amount to 20 decibels, or more and, a listener would perceive the newer engines to be only about one-quarter as loud as the earlier ones.

In my mind these reductions are primarily a result of three major developments: The change from pure jet to turbofan engines;

the use of acoustic treatment in engines and nacelles; and the development of theory that defines how to design a jet engine to prevent its fan, compressor, and turbine tones from propagating outside of the engine.

The change from pure jet to turbofan engines was driven by the desire to improve fuel consumption. In a pure jet, or turbojet engine, all the air passes through the hot core of the engine. In a turbofan, only part of the air passes through the hot core.

By moving a larger mass of air at lower velocity through the fan, it is possible to generate the same thrust, or power, as in a pure jet engine in a more efficient manner.

This reduction in velocity also results in a reduction in the noise generated by the turbulent mixing of the engine exhaust gases with outside air. This was the primary source of noise in the early jet engines.

The change to turbofan engines came in two steps. First was the development of turbofan engines with a bypass ratio of about one. Bypass ratio is defined as the ratio of the airflow going around the core of a turbofan engine to that flowing through its core.

These engines, namely, our JT3D and JT8D engines, entered service in the early 1960's, powering 707, DC–8, 727, 737, and DC–9 aircraft. Jet noise from these engines was about 10 decibels lower than that of the comparable pure jet engines.

The second step was the development of turbofan engines where about five times as much air went around the hot core as through it. These so-called high-bypass ratio engines, such as our JT9D, entered commercial service in the 1970's, powering 747 and DC–10 aircraft.

Going from low- to high-bypass ratio contributed another 10 decibels, or so, to the reduction in jet noise relative to the pure jet engines. Today's fleet of wide-body aircraft, as well as some of today's narrow-body aircraft, are all powered by high-bypass ratio engines.

The second major development, namely the use of acoustic treatment, occurred in the 1960's, at the same time we were developing the high-bypass ratio engines. Wherever practical, acoustic treatment was incorporated into the installation of these engines.

This treatment absorbed noise formed within the engine and lowered the noise reaching the community. Sound absorption meant increasing fuel consumption, engine weight, and cost. While sound absorption meant noise reductions on the order of five decibels, we had to pay penalties to achieve these reductions.

In the 1970's so-called hush kits, using acoustic treatment, were developed for JT8D engine installations to allow 727, 737, and DC–9 aircraft to comply with the FAA's stage 2 regulations. Extensive acoustic treatment is incorporated in all of today's modern engines.

The third major development, the design theory that minimizes turbomachinery tones, is related to the introduction of the turbofan engine. As I said earlier, noise from the pure jet engine was dominated by so-called jet noise. The fan section of the bypass engine introduced a new and significant source of noise at low and intermediate powers.

Engineers at Pratt & Whitney pioneered the development of theory that allowed the design of the fan section of the bypass engine to be optimized for low noise. This theory is also applicable

to the compressor and turbine sections of engines and is currently used by all manufacturers of large gas turbine engines for commercial aviation.

Today, the science of aircraft engine noise control is a mature science. Noise control is a basic part of engine design and development. We consider noise right along with performance, reliability, weight, and cost to arrive at an optimum configuration for a specified set of requirements.

As best we know, we've addressed all of the areas that offer large potential for noise reduction. The commercial aircraft being produced today, which are significantly quieter than their forebears, incorporate all technically practical and economically reasonable technology for noise reduction.

Future noise reductions will have to come from refinements to the control procedures already in use. These will be difficult and very expensive to develop and incorporate.

The next generation of engines may likely be geared turbofans or propfans. Current predictions place the noise of these engines in the vicinity of the quietest turbofans in service today. We and others are pursuing the technology needed to confirm the current estimates, as well as to ensure that these and other future engines will be as quiet as possible.

We at Pratt & Whitney have made large investments in dollars, time, and facilities over the past 25 years to reduce aircraft engine noise. Our efforts have brought a large payoff.

We're committed to the development of technology to reduce engine noise. As I said earlier, we spent over $5 million in search for additional noise reduction technology last year. This year, our effort is expected to be at least as large. We're confident that we will make progress. Thank you.

[The prepared statement of Dr. Goldberg follows:]

NOISE REDUCTION TECHNOLOGY

STATEMENT OF
UNITED TECHNOLOGIES CORPORATION
PRATT & WHITNEY

Prepared for

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON TRANSPORTATION, AVIATION,
AND MATERIALS

HONORABLE DAN GLICKMAN, CHAIRMAN
HONORABLE TOM LEWIS,
RANKING MINORITY MEMBER

Mr. Chairman and Members of the Subcommittee:

I thank you for the opportunity to appear before you today to discuss the status of jet engine noise reduction technology.

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In my mind, these reductions are primarily a result of three major developments: the change from pure jet to turbofan engines; the use of acoustic treatment in engines and nacelles; and the development of theory that defines how to design a jet engine to

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We're committed to the development of technology to reduce engine noise. As I said earlier, we spent well over $5 million in the search for additional noise reduction technology last year. This year, our effort is expected to be at least as large. We're confident that we'll make progress.

Thank you.

The CHAIRMAN. Thank you very much. Mr. Russell?

STATEMENT OF R.E. RUSSELL, CHIEF ENGINEER, NOISE TECHNOLOGY STAFF, THE BOEING CO.

Mr. RUSSELL. Mr. Chairman, members of the subcommittee:

My comments today will briefly describe the Boeing Co.'s three new technology airplanes and the noise reduction we have achieved with these machines. I will comment on our current research emphasis in noise reduction.

I will also discuss the airplane fleet replacement program that is currently underway, and the economic environment required by the airlines to introduce these new airplanes into the fleet and thereby realize the associated noise reduction potential.

The 767 is the first of our new generation, fuel efficient and quiet airplanes. The 767 has a body width that provides 2 aisle, 7 abreast seating, takeoff gross weights that range from 280,000 to 345,000 pounds, a flight distance ranging from 4,200 to 5,700 statute miles and carries from 216 to 290 passengers.

The 757 is our next new technology airplane. It has a standard body width, has maximum takeoff weights between 220,000 and 240,000 pounds, a range to 4,000 statute miles and carries 178 to 239 passengers.

The 737-300 is the newest of our new airplanes, and was FAA certified in the fall of 1984, with a takeoff weight of around 130,000 pounds, carrying 121 to 149 passengers, up to 2,700 statute miles.

All three airplanes comply with the most stringent noise certification requirements, and these are FAR-36 stage 3 and ICAO annex 16 chapter 3.

All three of our new airplanes have one important feature in common, and that is the use of the so-called high-bypass ratio engine for outstanding fuel economy, and for significantly lower community noise levels.

Compared to earlier turbofan and turbojet engines, the high-bypass ratio engine creates thrust by moving a larger mass of air and accelerating it to a lower velocity, resulting in lower noise than the older engines. The end result is higher propulsive efficiency and better fuel mileage, as well as a substantial improvement in noise for the community.

Steady progress has been made in reducing the noise of our airplanes to the point that now, on landing, engine noise is so low that we are working on the airframe noise, or the noise the airplane would make as a glider without engines.

Compared to early fan-jets, such as the 707's and DC-8's, reductions in landing noise of 10 to 20 EPNdB have been achieved, and are being realized in our new technology airplanes.

Reductions in sideline noise, which is also an indicator for takeoff noise, has been obtained through progressive improvements in engine technology from our early fan-jets to our new high-bypass ratio turbofan engines. Reductions of 10 to 20 EPNdB have been achieved.

Compared to the earlier technology of the low-bypass ratio powered airplanes, our new twins offer impressive noise reductions. The chart shows for comparison the 90 dB footprint area of older

airplanes in black, and the newer airplanes in white. The reduction in footprint area is from around 12 square miles to around 2 miles, or less.

I would not want to mislead you into thinking the progress just described can continue at its same rapid pace. Even though research is continuing to reduce engine and airframe noise, as with any maturing science or technology, our rate of progress into the future will be somewhat reduced. The easy and obvious steps to noise reduction have been taken.

Although the new generation of Boeing airplanes will meet the most stringent certification requirements, and significantly reduce airport community noise, Boeing is continuing its aggressive efforts in noise reduction research to meet the challenge of: First, local airport noise constraints that are in some cases more restrictive than certification requirements, and appear to be proliferating rather than subsiding; and second, the additional fuel efficiency available with advanced propeller-powered airplanes—these recently have been called ultra-bypass-engines—that present both interior and community noise challenges.

Our present research program includes testing of turbofan-powered airplane noise suppression concepts in full-scale ground test, and in the DNW—that is German and Dutch—wind tunnel, as well as propeller-airplane wind tunnel and full-scale demonstrator programs, conducted in conjunction with engine manufacturers and NASA.

With our now available advances in new low noise airplanes, one might question then, why isn't the noise reduction around airports more noticeable?

The answer lies in the fact that, for economic reasons, it takes some length of time to replace the older, noisier airplanes. The cost to replace older airplanes and to accommodate traffic growth between now and the year 2000 is immense; involving roughly 2,700 airplanes, requiring a capital outlay in excess of $100 billion in 1985 dollars.

Although the urge to have only these quieter airplanes operating is understandable, and would be desirable from an airplane manufacturers standpoint, the ability to accelerate the natural replacement process is questionable, and depends on the economics of the air transportation system.

Because of the greatly increased efficiency of these new airplanes, and in particular their improved fuel economy, an economic force now exists in the marketplace that will encourage this fleet replacement. An estimate of the U.S. fleet operation versus time is shown on the slide behind you, and reveals the relatively early phaseout of the older, nonnoise certified stage 1 airplanes. Further, the phaseout of the stage 2 airplanes, and the replacement by the quiet airplanes I have described, is also taking place.

Ironically, the continued operation of in-service airplanes is required to ensure the generation of funds to provide for the earliest possible replacement with quiet airplanes. In times of profit, the airlines are able to manage financing, and are able to purchase new technology airplanes. During times of economic stress, these purchases are substantially reduced.

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In summary, I would like to emphasize that new technology offering low noise and low fuel consumption is here. The means to ensure the implementation of this capability at the earliest possible time is to assist, in whatever ways possible, the development of a healthy airline transportation system. Thank you.

[The prepared statement of Mr. Russell follows:]

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS HEARING
APRIL 1, 1985

COMMENTS ON AIRCRAFT NOISE REDUCTION

R. E. Russell, Chief Engineer, Noise Technology Staff,
The Boeing Company

My comments today will briefly describe The Boeing Company's three new-technology airplanes and the noise reduction we have achieved with these machines. I will comment on our current research emphasis in noise reduction. I will also discuss the airplane fleet replacement program that is currently underway; and the economic environment required by the airlines to introduce these new airplanes into their fleet, and thereby realize the associated noise reduction potential.

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High Bypass Ratio Engines Make Much Less Noise

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Approach Noise Reduction

Steady progress has been made in reducing the noise of our airplanes, to the point that now on landing, engine noise is so low we are working on the airframe noise (or noise the airplane would make as a glider without engines)! Compared to early fan-jets such as 707's and DC-8's, reductions on landing approach of 10 to 20 EPNdB have been achieved, and are being realized in our new technology airplanes.

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Boeing Noise Reduction Accomplishments

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The Rate of Noise Reduction Progress Is Slowing

I would not want to mislead you into thinking the progress just described can continue at its same rapid pace. Even though research is continuing to reduce engine and airframe noise, as with any maturing science or technology, our rate of progress into the future will be somewhat reduced. The easy and obvious noise reduction steps have been taken.

Current Noise Reduction Research Emphasis

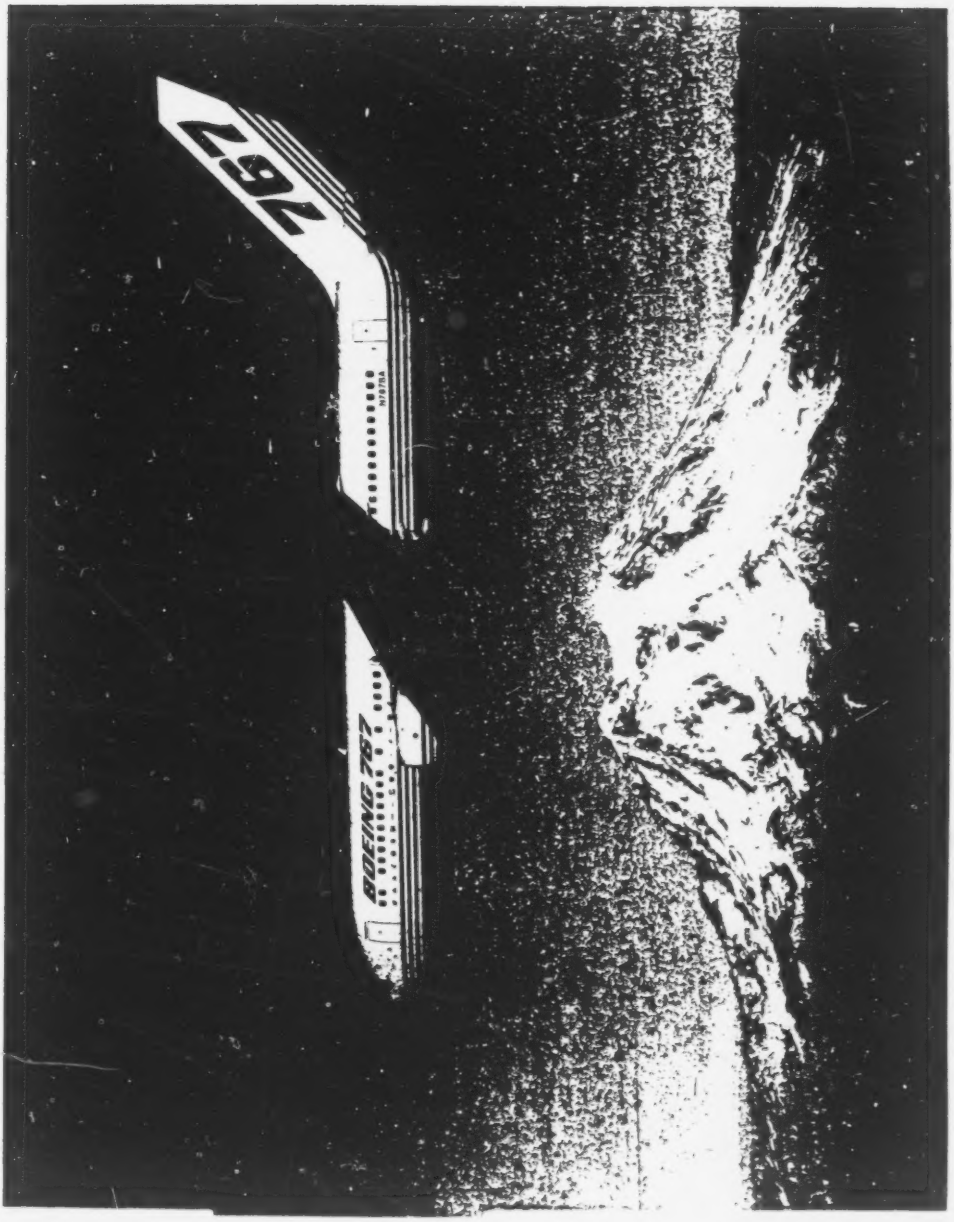
Although the new generation of Boeing airplanes will meet the most stringent certification requirements and significantly reduce airport community noise, Boeing is continuing its aggressive efforts in noise reduction research to meet the challenge of: (1) local airport noise constraints that are in some cases more restrictive than certification requirements, and appear to be proliferating rather than subsiding; and (2) the additional fuel efficiency available with advanced propeller-powered airplanes (recently called Ultra-Bypass-Engines) that present both interior and community noise challenges. Our present research program includes testing of

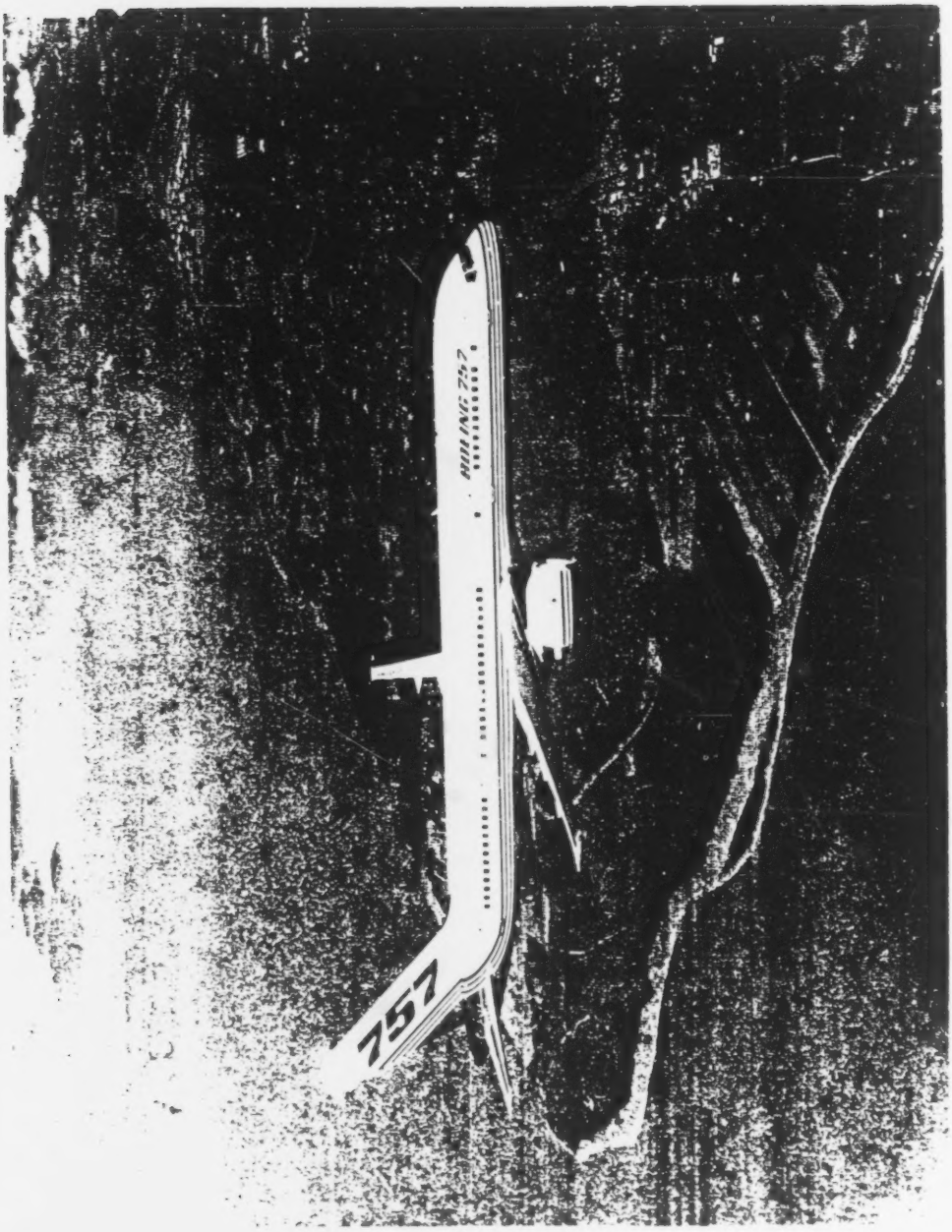
turbofan-powered airplane noise suppression concepts in full scale ground test and in the DNW (German and Dutch) wind tunnel, as well as propeller-airplane wind-tunnel and full-scale demonstrator programs, conducted in conjunction with engine manufacturers and NASA.

U.S. Fleet Replacement

With our now available advances in new low noise airplanes, one might question then, why isn't the noise reduction around airports more noticeable? The answer lies in the fact that, for economic reasons, it takes some length of time to replace the older, noisier airplanes. The cost to replace older airplanes and to accommodate traffic growth between now and the year 2000 is immense; involving roughly 2700 airplanes requiring a capital outlay in excess of $100B in 1985 dollars. Although the urge to have only these quieter airplanes operating is understandable, and would be desirable from an airplane manufacturers standpoint, the ability to accelerate the natural replacement process is questionable, and depends on the economics of the air transportation system. Because of the greatly increased efficiency of these new airplanes, and in particular their improved fuel economy, an economic force now exists in the market place that will encourage this fleet replacement. An estimate of the U.S. fleet annual operations vs time reveals the relatively early phase out of the older, non-noise certified Stage 1 airplanes. Further, the phase out of the Stage 2 airplanes, and the replacement by the quiet airplanes I have described is also taking place. Ironically, the continued operation of in-service airplanes is required to ensure the generation of funds to provide for the earliest possible replacement with quiet airplanes. In times of profit, the airlines are able to manage financing, and are able to purchase new technology airplanes. During times of economic stress these purchases are substantially reduced.

In summary, I would like to emphasize that new technology offering low noise and low fuel consumption is here. The means to ensure the implementation of this capability at the earliest possible time is to assist, in whatever ways possible, the development of a healthy airline industry.


767
BOEING 767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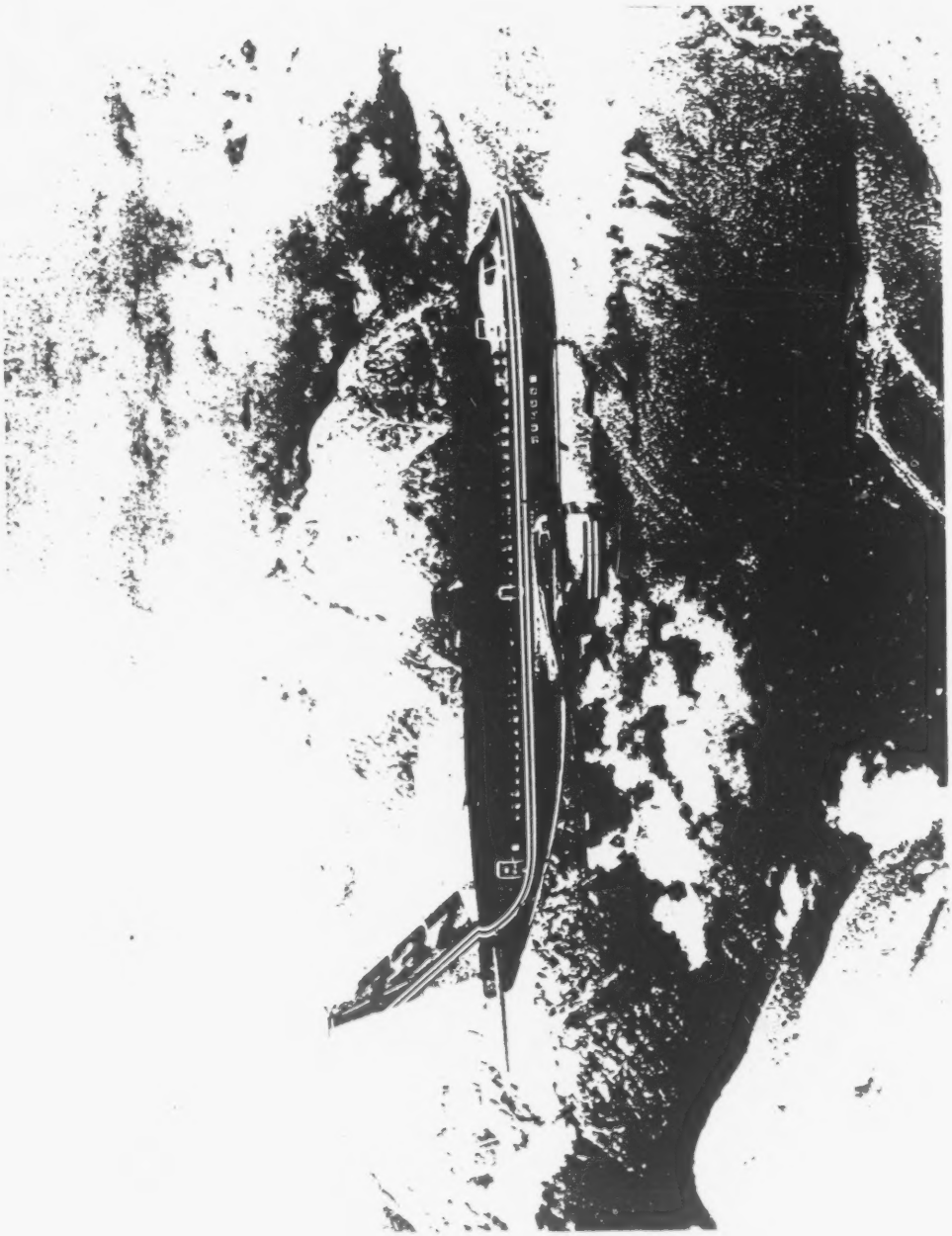
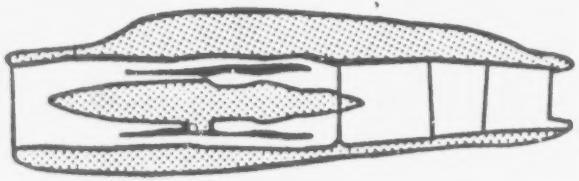


HIGH BYPASS RATIO ENGINES MAKE MUCH LESS NOISE

TYPICAL LOW BYPASS RATIO ENGINE

(JT8D)



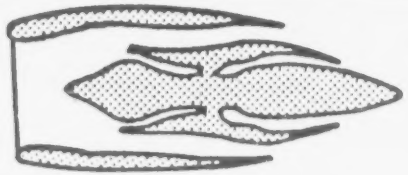
AIR MASS

HIGHER JET VELOCITY

HIGHER JET NOISE

TYPICAL HIGH BYPASS RATIO ENGINE

(CFM56)



LARGER AIR MASS

LOWER JET VELOCITY

LOWER JET NOISE

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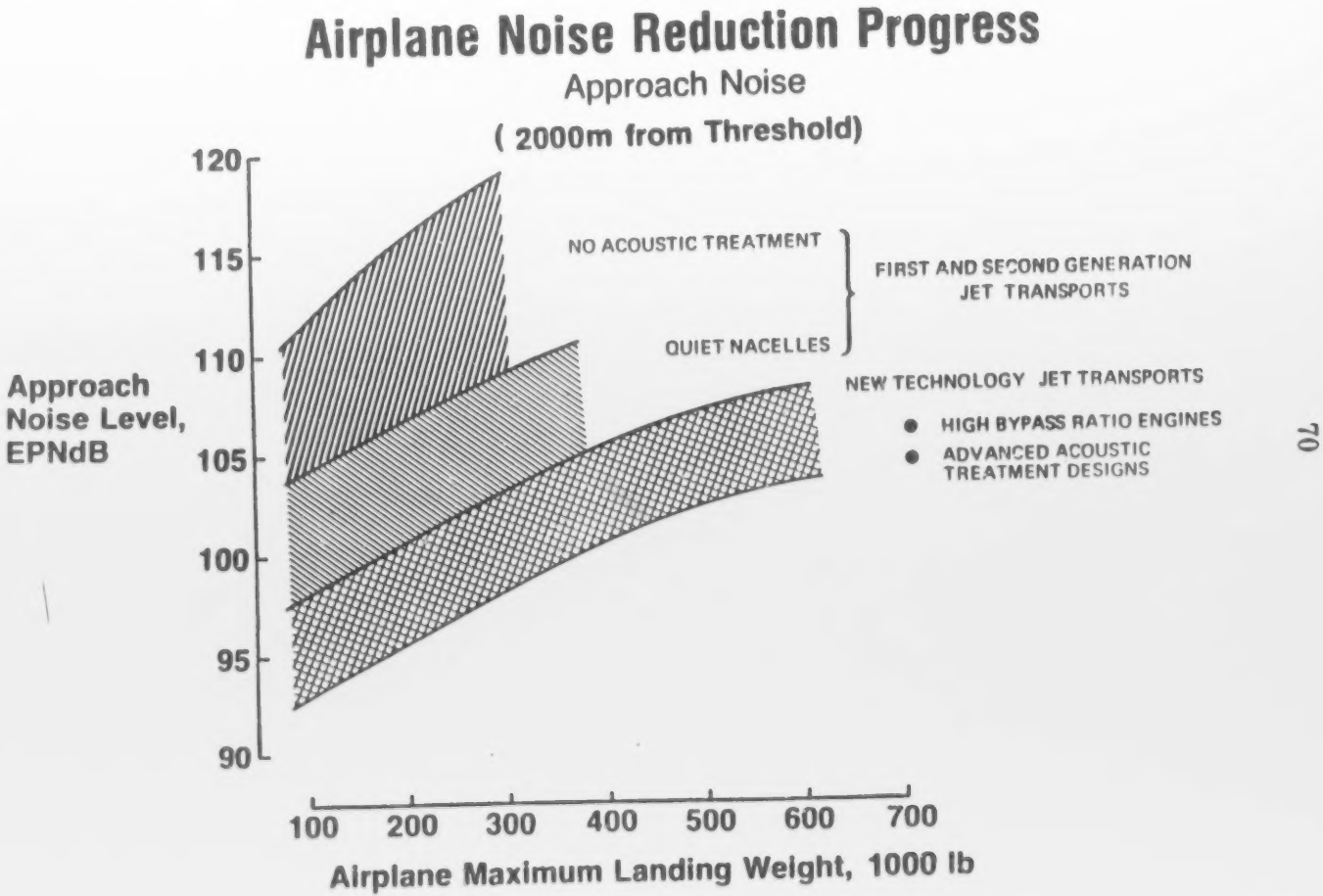
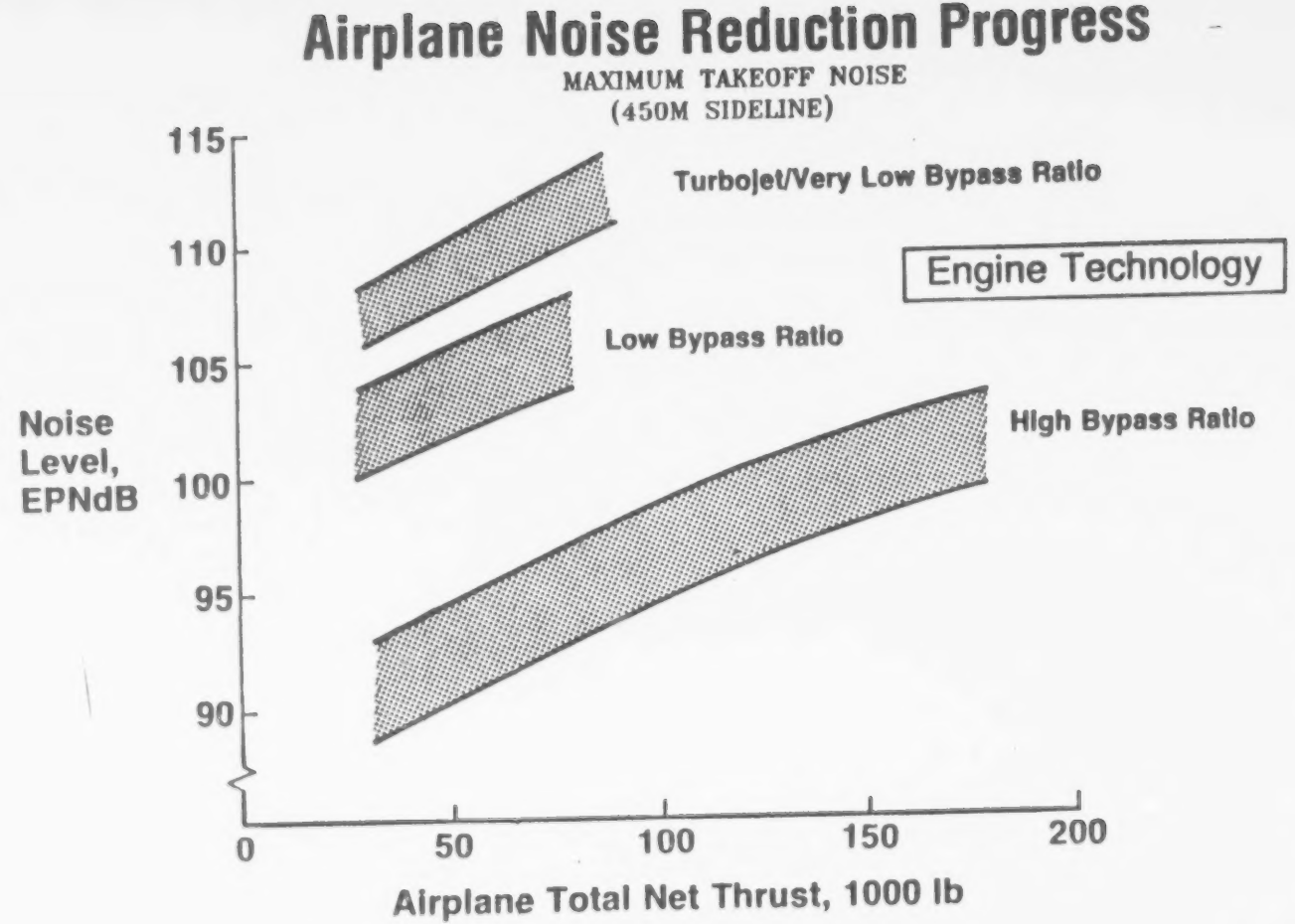
Airplane Noise Reduction Progress

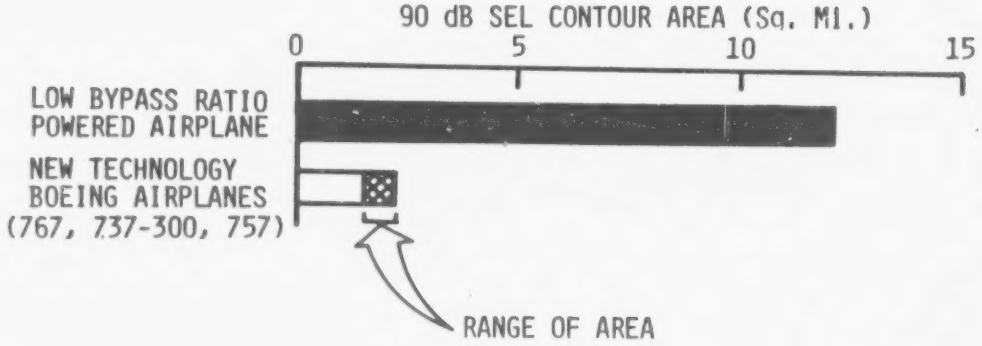


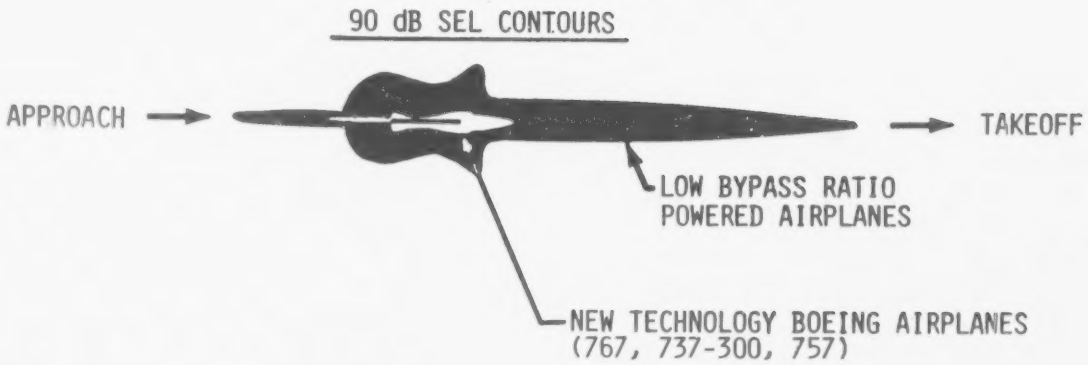
Airplane Noise Reduction Progress



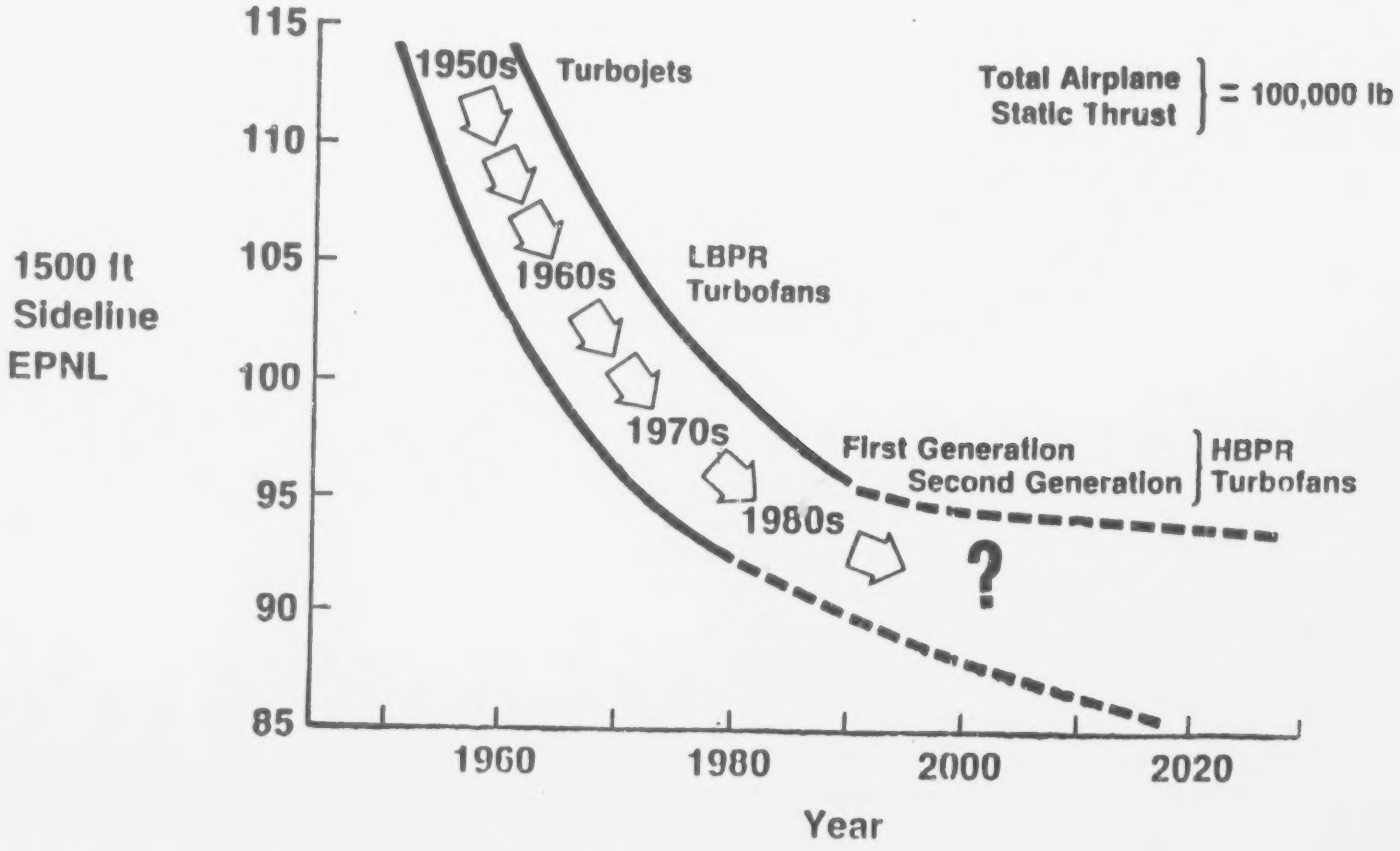
BOEING NOISE REDUCTION ACCOMPLISHMENTS

TAKEOFF AND APPROACH



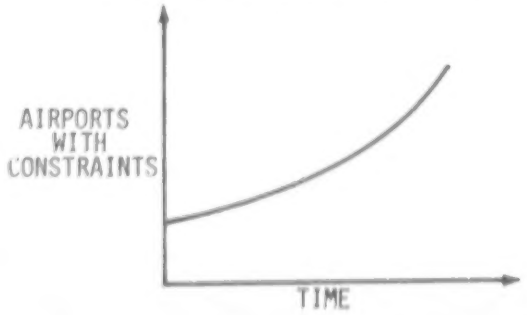


The Rate Of Noise Reduction Progress Is Slowing



TURBOFAN-POWERED AIRPLANES

AIRPORT CONSTRAINTS INCREASING

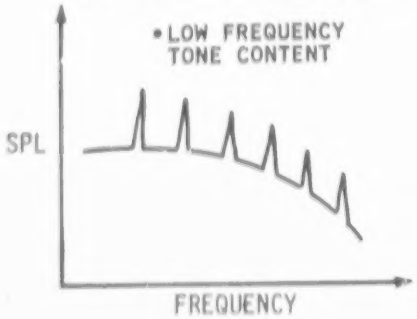


WIND TUNNEL MODEL INVESTIGATIONS

- AIRFRAME NOISE REDUCTION
- JET NOISE REDUCTION

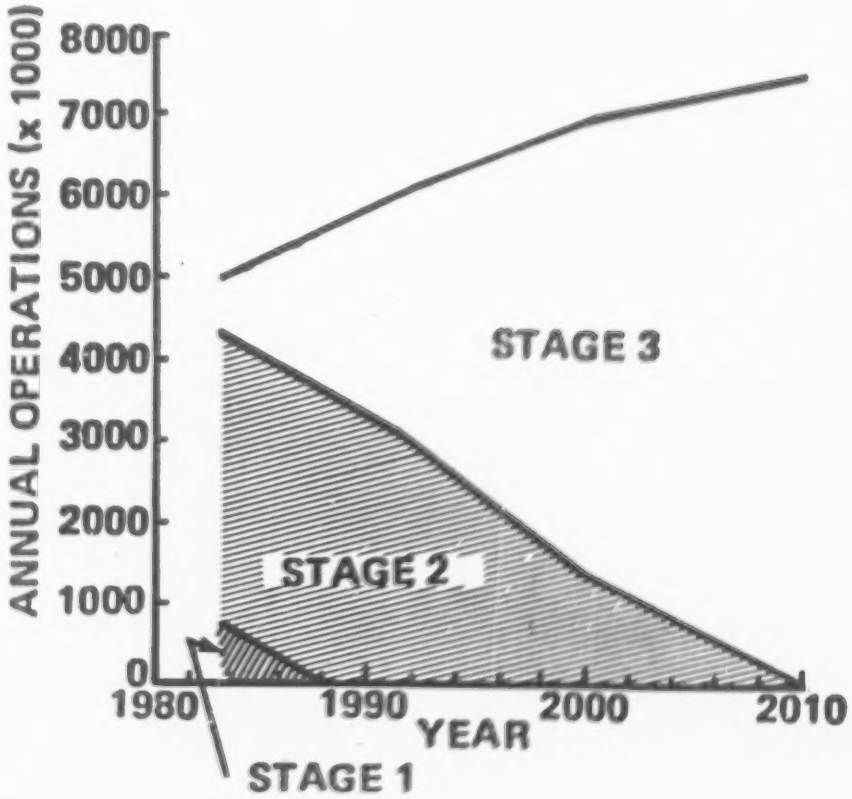
PROPELLER-POWERED AIRPLANES

INTERIOR/COMMUNITY PROPELLER NOISE SOURCES



COUNTER-ROTATING PROPELLER

U.S. FLEET REPLACEMENT ESTIMATE



The CHAIRMAN. Thank you very much. Mr. Cooper.

STATEMENT OF KEVIN E. COOPER, DIRECTOR, OPERATIONS SERVICES SUPPORT, EASTERN AIR LINES

Mr. COOPER. Mr. Chairman and members of the committee.

I would first like to review the progress made to date in introducing quieter aircraft into Eastern's fleet.

The requirement for low noise is a key parameter in any of our aircraft evaluation studies. Eastern was the first major airline to retire all of its noisy four-engined Boeing B-720 and Douglas DC-8 turbojets. This occurred back in 1970 to 1973.

Since 1972, Eastern has continually led the industry by being the first operator of each successive quietest turbojet in the United States, and our fleet numbers as follows:

April 1972, we introduced the L-1011 aircraft; August 1977, the A-300; in December 1982, the Boeing 757 with a Rolls engine, the 535C.

In October 1984, we began to introduce a later version of the 757, the RB211535E4.

The introduction of all this new technology has required a huge investment. In addition, our bill for retrofitting DC-9's and B-727's with hush kits, since 1980, will total $33 million. This, of course, is at a time when the company has been experiencing annual financial difficulties.

The greatest technological improvement in noise reduction has come from the high-bypass engines. The engine manufacturers have all invested sums of money in noise research, which of course is reflected in the price paid by airlines for new technology aircraft.

Apart from purchase costs, our aircraft now carry a significant amount of added weight for noise suppression purposes. For our total 727 and DC-9 fleet, this added weight amounts to 31 tons, and an associated added fuel burn to carry it, of 1.2 million gallons per year.

Eastern's fleet planning, and that of many major airlines, in 1970, projected a lot more high bypass aircraft being purchased in the 1980's. For example, it was expected that 727's would soon be retired in favor of 757's and other larger aircraft.

However, deregulation and the proliferation of new low-fare carriers forced greater emphasis toward service frequency and the smaller turbojets. Hence, the industry's 727's, 737's, and DC-9's are being retained longer and the replacement cycle is slowed.

New production aircraft since December 1973 have had to meet FAR 36 stage 2 noise rules. In fact, Eastern voluntarily complied with this rule by having 15 aircraft deliveries with full noise suppression before that date.

Then, in 1977 the more stringent FAR 36 stage 3 noise rules were introduced, and the stage 3 aircraft in the Eastern fleet, as I stated previously, include the L-1011, A-300, and B-757.

Eastern, along with British Airways, was the launching customer for the 757, and worked closely with Boeing in the design phase. One of our initial requests was that extra powerful engines be incorporated in order to obtain a high thrust-to-weight ratio so that

in everyday operations the engines would have increased potential for operating at derated conditions.

Even though the 757 with the RB211-535C engines was the quietest, most fuel efficient airliner when introduced to Eastern in late 1982, we are now reengining these aircraft with the latest Rolls Royce RB211-535E4 engines for even better fuel efficiency and lower noise. The total cost of this conversion program is $23 million.

Eastern converted its first aircraft in Atlanta last month, and anticipates completion by the end of 1985. The E4 engine is quieter due to the advanced technology wide-chord fan blades and an exhaust stream mixer in the tailpipe.

For the longer term, NASA and the manufacturers are researching the possibility of propfan airliners, which could yield noise benefits in the 1990's. Eastern has actively supported this research work since 1980, and we have recently received presentations from both General Electric and Pratt & Whitney on the state of propfan development.

Over the years since jets were introduced, Eastern has spent many dollars in evaluating the quietest operational procedures for the aircraft we fly. Much of this work has involved our contribution to joint industry efforts via our membership in the Air Transport Association, and our management pilots and engineers, who have been active participants in noise committees and have worked closely with the FAA, NASA and airport managements and local community noise groups.

The goal has always been to devise the best takeoff and landing flight profiles and techniques for lowest noise, consistent with not creating a safety hazard.

Extensive simulator time has been spent in these evaluations. Real aircraft flight tests have also been performed and demonstrations conducted. For example, we demonstrated, for evaluation purposes, the A-300 and the 757 at Washington National Airport. All of these demonstrations were preceded by extensive simulator evaluations.

Eastern supports and consistently uses the standard industry noise abatement takeoff procedures. Since the noise sensitive areas vary geographically from airport to airport, there had to be some compromise in reaching the standard procedure, which is considered to be the optimum for noise and safety.

Each airport is different, and one of our concerns regarding the proliferation of local airport rules concerning noise would be the erosion of safety margins due to having many different procedures.

Any revisions to current noise abatement profiles should be reviewed with industry representatives before their enactment.

For example, any proposal to lower the altitude for engine cutback must give consideration to the effects of windshear and other factors.

The pilot must always anticipate the possibility of an engine failure, or other emergency, occurring during this time.

Eastern devotes significant training time for each pilot in terms of flight manual and simulator reviews, to ensure compliance with recommended noise abatement procedures. Any noise complaints, such as are derived from noise monitoring computers, are forward-

ed to the chief pilot at the relevant crew base for explanation and followup by the crew member.

As well as emphasis on engine power management to minimize aircraft noise, it is also desirable to keep the aircraft as aerodynamically clean as possible. On takeoff, this means retracting the flaps at the best time. During landing, pilots try not to extend the landing gear and flaps prematurely, and usually land with"one notch less than maximum" landing flaps.

The latter requires a higher touchdown speed and hence costs the airline additional expenses in tire and brake wear.

Another noise reduction technique is the "keep 'em high" effort in conjunction with air traffic control. In general, these energy management techniques also save fuel.

Also in cooperation with Air Traffic Control, there are programs for preferential runway use and fan headings for departure which spread out the noise more evenly. Such a system was recently introduced here at West Palm Beach.

We are working with the FAA toward a service evaluation of the Microwave Landing System for our Air-Shuttle A-300's. This could lead to curved approaches and spread the noise along different paths for landing.

In summary, therefore, Eastern has been a leader since 1978 in supporting noise reduction through the procurement of new technology aircraft, development of new procedures, and the modification of existing aircraft.

We plan to retain this leadership position as new technology, such as the propfan and MLS is developed. Thank you.

[The prepared statement of Mr. Coooper follows:]

KEVIN E. COOPER, EASTERN AIRLINES, INC. STATEMENT

BEFORE THE

HOUSE SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

APRIL 1, 1985

WEST PALM BEACH, FLORIDA

Mr. Chairman:

My name is Kevin E. Cooper, my position is Director-Operations Services Technical Support for Eastern Airlines. We appreciate the opportunity to appear before this subcommittee on the subject of noise reduction technology and operational procedures.

I would first like to review the progress made to date in introducing quieter aircraft, incorporating the latest state-of-the-art noise technology, in the Eastern fleet. The requirement for low noise is a key parameter in any of our aircraft evaluation studies. Eastern was the first major airline to retire all its noisy four-engined Boeing B-720 and Douglas DC-8 turbo-jets back in 1970-1973. Since 1972, Eastern has continually led the industry by being the first operator of each successive quietest turbo-jet in the U.S. airline fleet:

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The introduction of all this new technology has required a huge investment. In addition, Eastern's bill for retrofitting DC-9's and B727's with hush-kits since 1980 will total $33 million--at a time when the company has been experiencing annual financial losses.

The greatest technological improvement in noise reduction has come from high bypass engines. The engine manufacturers have all invested huge sums in noise research, which of course is reflected in the price paid by the airlines for new technology aircraft. Apart from purchase costs, our aircraft carry a significant amount of added weight for noise suppression purposes. For the

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New production aircraft since December, 1973 have had to meet FAR 36 Stage 2 noise rules. In fact, Eastern voluntarily complied with this rule by having fifteen aircraft deliveries with full noise suppression before that date (although they could have flown untreated until January 1, 1983). Then, in 1977 the more stringent FAR 36 Stage 3 noise rules were introduced. Stage 3 aircraft in the Eastern fleet include the L1011, A300, and B757.

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The goal has always been to devise the best takeoff and landing flight profiles and techniques for lowest noise--consistent with not creating a safety hazard in any way. Extensive simulator time has been spent in these evaluations. Real aircraft flight tests have also been performed and demonstrations conducted. For example, we demonstrated for evaluation purposes the A300 Airbus and B757 at Washington National Airport. All of these demonstrations were preceded by extensive simulator evaluations.

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Eastern devotes significant training time for each pilot in terms of flight manual and simulator reviews to ensure compliance with recommended noise abatement procedures. Any noise complaints, such as derived from noise monitoring computers, are forwarded to the Chief Pilot at the relevant crew base for explanation and follow-up.

As well as emphasis on engine power management to minimize aircraft noise, it is also desirable to keep the aircraft as aerodynamically clean as possible. On takeoff, this means retracting the flaps at the best time. During landing, pilots try not to extend the landing gear and flaps prematurely and usually land with "one notch less than maximum" landing flaps. The latter requires a high touchdown speed and hence costs the airline additional expense in tire and brake wear. Another noise reduction technique is the "keep'em high" effort in conjunction with air traffic control. In general, these energy management techniques also save fuel. Also in cooperation with ATC there are programs for preferential runway use and "fan headings" for departure which spread out the noise more evenly--such a system was recently introduced here at West Palm Beach. We are working with the FAA towards a service-evaluation of MLS (Microwave Landing System) for our Air-Shuttle A300's. This could lead to curved approaches and spread the noise along different paths for landing.

Since 1978 Eastern has been a leader in supporting noise reduction through procurement of new technology aircraft, development of new procedures, and the modification of existing aircraft. We plan to retain this leadership position as new technology such as the prop-fan and MLS is developed.

The CHAIRMAN. Thank you very much. Finally, our last witness today is Mr. Irwin.

STATEMENT OF KIRK IRWIN, VICE PRESIDENT, ENGINEERING AND DEVELOPMENT, TRACOR AVIATION, GOLETA, CA

Mr. IRWIN. Mr. Chairman and members of the subcommittee, it is a pleasure and an honor to be here to provide to the Transportation, Aviation and Materials Subcommittee the current status report on the Tracor-Shannon Quiet 707 Program.

The Quiet 707 concept was first developed by Shannon Engineering of Seattle, WA, in early 1982. It was in mid-1983 that Comtran, a Texas limited partnership, made the decision to sponsor the program.

In referring to the first chart, which is a statement of the problems that you are all very familiar with, January 1, 1985, the 707, and also the DC-8 aircraft, became noncompliant with Federal Aviation regulations.

On January 1, 1988, the 707 will no longer be in compliance with noise regulations throughout most of the rest of the world, due to the ICAO annex 16, chapter 2 rules.

With over 400 707 aircraft still actively flying, or at least available to be operated, throughout the world, this presented a serious economic problem to the owners and operators.

They really had only three choices, which are shown in the second figure; that is, replacement with new aircraft and that's in the range of $30 to $60 million a piece, in some cases, and it becomes a very expensive solution. Also, there really are no new aircraft that ideally replace the specific payload and route characteristics of Boeing's 707 aircraft.

The second choice would be to reengine the aircraft, similar to the program that CAMMACORP has accomplished with the DC-8. Although not mentioned in my text, that is approximately an $18 million modification per airplane.

Boeing did reengine one 707 a number of years ago and concluded, from a market evaluation, that such a program for the 707 was not economically viable. Yes, I did say here, the DC-8 program is $18 million per aircraft.

The third, and more viable alternative, was to modify the 707 with the hush kit, a noise attenuating treatment to the existing nacelles. It is this latter alternative that led to the birth of the Quiet 707 Program.

In the third chart, we show that the Shannon Engineering approach to quieting the 707 is what we would call "an optimized solution." This optimized solution consists of three parts:

The first is to treat as much of the existing nacelle as possible with the noise attenuating material. Analytical predictions of the noise reduction, due to the acoustic treatment itself, indicated that the aircraft with this treatment alone would not be quiet enough to meet the stage 2 requirements.

The second step, therefore, in optimizing this, was to use 25 degree flaps for landing instead of 50 degrees. The smaller landing flaps setting requires less thrust, and less thrust means less noise.

The third part is to make a small reduction in the aircraft's maximum takeoff weight. By taking off with a lighter weight, the aircraft climbs faster and goes over the measurement station at a higher altitude, resulting in less noise at that point on the ground. Early feasibility studies indicated that this optimized solution would achieve the noise reduction objective, would be certifiable and would lead to an economically and operationally viable hush kit in the shortest period of time.

On the fourth chart, it shows an organization that was developed to actually implement this program. I won't elaborate with all the words here. Comtran, Ltd., a Texas partnership, engaged Tracor Aviation to manage the program and perform portions of the design. We, in turn, subcontracted Shannon Engineering, the developer of the concept for FAA certification processes and portions of the analysis.

Then we contracted with Rohr Industries, the country's leading manufacturer of nacelles, to do the acoustic modification of the 707 nacelles.

The fifth chart shows the basic modification to the nacelle, itself, and in it, it illustrates that we first take and modify the nose cowl, or the inlet to the engine by putting acoustic treatment in the inner liner.

Next we add a 14-inch extension to the nose cowl, which allows a larger area of liner in the nose cowl to give us more treated area for noise reduction.

The final step is the extension of the bypass fan exit, by a little over 1 foot, and treating that extension with the acoustic material.

The acoustic material that I am—by the way, I wanted to mention at this point, and again, it's not in the text, but this concept and that particular, the treatment you're seeing here, is an outgrowth of the NASA and FAA and Boeing Programs of the late 1960's, early 1970's time period.

So this whole concept, and much of the materials technology, has developed from the Government sponsored research work in that era.

Particularly in figure 6, you will see an illustration of the acoustic material that is used. It is a proprietary product of Rohr Industries, and the name of it is DynaRohrTM. DynaRohrTM is a honeycomb material consisting of a solid aluminum skin bonded to an aluminum honeycomb core, which in turn is bonded to a perforated aluminum skin. Then, a very critical part of this material, a finely woven steel mesh is bonded onto the perforated aluminum skin, forming the DynaRohrTM panel.

In figure 7, the DynaRohrTM material is an excellent structural product with very good strength-to-weight ratios. The woven cloth produces a linear acoustic structure, which means that it does not have a significant variation in acoustic properties with the air speed or the air flowing over it.

The smooth surface of the wire mesh minimizes the aerodynamic drag, and this material is very efficient, acoustically, over a wide range of frequencies, meaning that it provides good attenuation of the noise over a wide range of aircraft operating conditions and engine power settings.

Figure 8 illustrates that this is not a new product, but is one that has been in actual airline service now for one decade, beginning with the 737–200 and on through a good many of the new generation of aircraft that have developed over the last 10 years.

In figure 9 you can see a cross section of the nose cowl to see how the material has been inserted into the nose cowl, in the nose cowl, itself, and the 14-inch extension.

That is followed by a photograph where you can see the actual product after it has been completed. It becomes a very aerodynamically clean nose cowl, and very acoustically efficient. This treatment virtually eliminates the objectionable high frequency whine which is characteristic of the compressor of this generation of engine.

Figure 11 illustrates what we have done to the fan duct to extend it aft, and to add the DynaRohrTM treatment on the inner and the outer walls. This completes the acoustic package that is used for the noise reduction in the nacelle itself.

Figure 12 is a photograph of the completed package without certain doors on, but all of the acoustic treatment is in place. When we are done we have only increased the weight of each nacelle by 210 pounds, or the weight of the entire airplane by only 840 pounds.

The 13th figure is simply another picture which shows some of the equipment in place.

Before we began the actual modifications of an airplane, we tested the product by putting it on a test stand in San Diego, actually at the Brownfield facility, south of Chula Vista, CA, one of only four facilities in the United States that is capable of doing this quality of noise testing.

Figure 14 shows our prototype engine installed on Rohr's test facility there. The array of microphones that was used is shown in figure 15.

We're very encouraged by the results of these tests, and then proceeded with the program to launch our prototype aircraft for flight tests.

The first thing we did was to have a baseline airplane, or an unmodified airplane tested, which is shown in the photograph of figure 16.

The baseline program consisted of acquiring data in flutter and performance, stability, control, et cetera, so that we could compare it with the modified airplane.

We then took and put the kit on the airplane, and you see in figure 17 a photograph of the actual Quiet 707 hush kit, installed on the Boeing 707 aircraft.

When that installation had been completed, a comprehensive flight test program was conducted, which included flutter, vibration, performance, aircraft flying qualities, engine operating characteristics, and of course, the acoustic measurements, because as has been mentioned earlier, noise is the principal objective of this program, but safety comes even before that.

So full air worthiness flight test certification processes were required as a part of this project.

Figure 18 is similar to one shown by Mr. Wesler that shows the different points at which the acoustics are measured.

In 19 you see the aircraft during the actual test program, flying over the microwave landing station, and this is not actually used for the traditional purposes of microwave landing equipment, but we used it as a way of positioning the airplane accurately on the approach profile or the climb out profiles, and of measuring the on-board space positioning data that was needed in the analysis.

Illustration No. 20 shows the aircraft on a takeoff climb out going over one of the center line microphones. We had an array of microphones that were placed in position by Bolt, Bairnick & Newman, a firm that specializes in this type of testing, and they acquired and reduced the data from a series of microphones at center line and off to the side of the flight path.

The bottom line figure is No. 21. This is the results, and although there is a lot of information on this, I'll summarize it.

The noise levels; on side line, the aircraft came out under the regulatory limits; on approach, it was slightly under the regulatory limits for stage 2; and on takeoff, by offloading to 320,000-pound maximum gross weight, instead of 356,000, the aircraft met the stage 2 limit, with the permitted two decibel trade applied.

So the aircraft, as certified, has a 321,000-pound break release gross weight, a full 247,000-pound landing gross weight, 25 degree flaps for approach and landing, and it does meet the stage 2 requirements.

The next figure, No. 22, shows the footprint profile for the 100 EPNdb, and you see that the Quiet 707 is significantly reducing the noise profile in the vicinity of the airport.

In figure 23, we show that even though we have gone to the 25-degree flap setting, that has not degraded the performance of the aircraft significantly.

The left figure there illustrates that the increase in speed on approach and landing is only six knots, and that the increase in landing distance, on the right hand side, is under 800 feet at sea level, and at higher altitude is just slightly longer.

We've done route analyses for our customers and have found, essentially, no significant impairment of their operations due to these field length increases for landing.

Figure 24 is the certificate, itself, and this became the culmination of many months of design and manufacturing, testing, when we received this certificate on February 22 of this year. That meant that we had complied with all of the applicable regulations, air worthiness as well as acoustics.

Since that time, in fact, really before that time, with certification in hand, the production program is underway.

Advanced production work actually was initiated in May of 1984. The production effort is now in full pace.

Illustration No. 25 shows some of the hush kit fabrication and assembly operations that are taking place at Tracor's facilities in Santa Maria, CA.

No. 26 is a picture of one of the assemblies going together at Rohr's facility. This is actually in Chula Vista. They also do manufacturing in Riverside, CA.

Then, figure No. 27 shows one of the kits being installed on an airplane at our Santa Barbara facilities of Tracor Aviation.

Figure 28 is the delivery status. Our first production delivery will actually take place this week. We have 48 sales at this point; 48 contracts and a number of options, in addition to that.

Our minimum number of deliveries this year will be 30, and we plan a rate of 5 per month; between 4 and 5 per month. I think the text says four and the chart says five, but we will range between four and five per month for 1986.

With the sales that we are at right now, our next open slot is in March of 1986 for any customers that may come in from this point on.

The price of the kit is now at $2.5 million per installation; that's a completely installed kit.

The quiet 707 is an example of the application of new technology——

The CHAIRMAN. Is that per engine or per aircraft?

Mr. IRWIN. No, per aircraft.

The CHAIRMAN. Per aircraft.

Mr. IRWIN. That's fly it in and fly it away, per aircraft.

We are very pleased with what we have been able to do, applying this technology. We are pleased to have had the opportunity of the technology development that was done through the quiet nacelle program in prior years, and we believe that what we have done here is going to help keep the 707 a good neighbor for a long time to come. Thank you.

[The prepared statement of Mr. Irwin follows:]

Tracor Aviation

Tracor Aviation, Inc.
4335 South Fairview Ave
Goleta, California 93117
Telephone 805 967-4571

A Status Report on the

Tracor/Shannon Quiet 707

Presented on Behalf of Comtran, Ltd. by

Kirk S. Irwin

Vice President of Engineering and Development

Tracor Aviation, Inc.

to

The Subcommittee on

Transportation, Aviation and Materials

of the

Committee on Science and Technology

of the

United States

House of Representatives

April 1, 1985

Tracor Aviation

It is a pleasure and an honor to provide to the Transportation, Aviation and Materials Subcommittee of the House Committee on Science and Technology a current status report on the Tracor-Shannon Quiet 707 Program. The Quiet 707 concept was first developed by Shannon Engineering of Seattle, Washington in early 1982. In mid-1983 Comtran, a Texas limited partnership, made the decision to sponsor the program. Comtran engaged Tracor Aviation to manage the Quiet 707 program on their behalf. I am here for Comtran, Ltd. to give you the background and current status of our project. You will see how we have applied new technology materials and processes to older technology aircraft and engines bringing the Boeing 707 aircraft into compliance with current Federal Aviation Administration noise regulations.

The problem simply stated is that on January 1, 1985, the 707 aircraft became non-compliant with Federal Aviation regulations Part 36. On January 1, 1988, the 707's will no longer be in compliance with Noise Regulations throughout most of the rest of the world due to ICAO Annex 16 Chapter 2.

With over ~~forty~~ 400 707 aircraft still actively flying throughout the world, this presented a serious economic problem to the owners and operators. They basically had only three possible solutions. One, they could scrap their aircraft and go out and buy new models to replace them. With the cost of new air transport aircraft being in the range of $30-60 million each, that represents a very expensive solution. Also, there are no new aircraft that ideally replace the payload/route characteristics of Boeing 707 aircraft. Their second choice would be to reengine the aircraft similar to the program that CAMMACORP has accomplished with the DC-8.

Boeing did reengine one 707 a number of years ago and concluded from a market evaluation that such a program is not economically viable. The DC-8 reengine program costs approximately $18 million per aircraft. The third and more viable alternative was to modify the 707 with a Hush Kit, a noise attenuating treatment to the existing nacelles. It is this latter alternative that led to the birth of the Quiet 707 Program.

The Shannon Engineering approach to quieting the 707 is what I would call "an optimized solution". This optimized solution consists of three parts. The first part is to treat as much of the existing nacelle as possible with noise attenuating material. Analytical predictions of the noise reduction due to the accoustic treatment itself indicated that the aircraft with this treatment alone would not be quiet enough to meet the noise regulations. The second step, therefore, in the optimized solution is to use 25° flaps for landing instead of the normal 50° setting. The smaller landing flap setting requires less thrust, and less thrust means less noise. The third part is to make a small reduction in the aircraft's maximum take-off weight. By taking off with a lighter weight the aircraft climbs faster and goes over the measurement station at a higher altitude resulting in less noise at that point on the ground. Early feasibility studies indicated that

this optimized solution would achieve the noise reduction objective, would be certifiable, and would lead to an economically and operationally viable Hush Kit in the shortest period of time.

When the Tracor/Shannon Quiet 707 program was launched in the fall of 1983, the program organization was structured as follows. Comtran, Ltd. engaged Tracor Aviation to manage the overall program and to perform selected technical functions in engineering, tooling, and marketing support. In turn, Tracor Aviation sub-contracted to Shannon Engineering the tasks of carrying out the certification with the FAA in Seattle, Washington, and many of the engineering analyses that were integral parts of the certification program. Tracor also sub-contracted to Rohr Industries of Chula Vista, CA the design of the acoustic modifications to the nacelles, the ground testing of a prototype Quiet 707 Kit, and the fabrication and assembly of the acoustically modified nacelle components. The members of this technical team - Tracor, Shannon, and Rohr - made a very strong program organization for Comtran. Tracor Aviation is one of the nation's top aircraft modification firms, having developed the famous Super Guppy aircraft and performed many other major modification projects. Shannon Engineering not only developed the Quiet 707 concept but is well recognized as a highly capable engineering firm for FAA certification, engineering analysis, and aircraft flight testing. Rohr Industries is without any doubt our country's leading manufacturer of aircraft nacelles.

The central feature of the Quiet 707 is the way that the nacelle is acoustically modified to reduce the noise. The modification consists of several elements (Figure 5):

1. Replacement of the aluminum skin in the inner wall of the nose cowl with an acoustical liner.

2. Extending the nose cowl and nose dome forward 14". Those inner and outer barrel extension sections are made totally of the acoustic liner material.

3. Extending the fan exhaust duct aft a little over 1 foot using the acoustic liner material for the inner and outer wall of the extended duct.

The acoustic material used is a proprietary product of Rohr Industries named DynaRohr^{Tm}. DynaRohr^{Tm} is a honeycomb sandwich material consisting of a solid aluminum skin bonded to an aluminum honeycomb core which in turn is bonded to a perforated aluminum skin. A very finely woven steel mesh is bonded onto the perforated aluminum skin. (Figure 6)

The DynaRohr™ material is an excellent structural product. It has good strength-to-weight ratios making it a very suitable material for use in aircraft construction. The very fine woven cloth produces acoustic characteristics which are linear with air velocity. That means the acoustic properties of the material do not change significantly with the air speed of the aircraft. The woven cloth is also quite smooth minimizing aerodynamic drag. The most important characteristic of DynaRohr™ is that it works very well acoustically over a wide range of frequencies. This means that the material will attenuate the noise effectively over a wide range of airplane operating conditions and engine power settings.

Although DynaRohr™ is a current state of the art product it is by no means new. DynaRohr™ has been in service on air transport class aircraft for one decade now. (Figure 8) It was first introduced on the Boeing 737-200 aircraft up to and including the latest aircraft produced by Boeing, McDonnell Douglas, and Airbus Industries. The Quiet 707 program simply applies this modern technology to former generation aircraft and engines.

Let us look briefy at each portion of the acoustic modification. First the nose cowl (Figure 9). As I mentioned previously the inner skin of the nose cowl is removed and replaced with a section of DynaRohr™. A cylindrical 14" barrel section of DynaRohr™ is added to extend the nose inlet. The center nose dome is similarly moved forward 14" by a smaller barrel section of DynaRohr™. The result is an aerodynamicly clean, lengthened nose cowl with efficient acoustical treatment that effectively reduces the noise emanating forward out of the engine compressor. This treatment virtually eliminates the objectionable high frequency whine which is characteristic of the compressor of this generation engine.

The remainder of the modification is the extension of the fan exhaust duct. Noise emanating from the fan duct is the second major source of noise that must be reduced to bring the 707 into regulatory compliance. By lengthening the fan exit duct approximately 13" and using DynaRohr™ for the inner and outer walls of the extended duct, the remainder of the needed noise reduction is achieved.

When fully modified the weight of each nacelle is increased by only 210 pounds or a total weight increase for the airplane of just 840 pounds. No modifications are necessary to any of the engine or aircraft systems, and all DynaRohr™ components are easily removed to facilitate engine maintenance.

The first step after designing the Quiet 707 modifications was to test it. Before proceeding with lengthy and expensive flight

tests, a prototype modification was tested on the ground at Rohr Industries engine test facility south of San Diego, CA (Figure 14). A comprehensive set of engine tests were run to establish the acoustic performance of the modification and to determine if the nacelle changes would effect the engine thrust or operating characteristics. The Rohr test facility is one of only four such facilities in the United States qualified to make the necessary measurements. A complete array of microphones (Figure 15) surrounded the test engine to obtain the noise data over a wide range of engine operating conditions. When analyzed, results of the ground tests confirmed that the design goals had been met and provided the justification to proceed into the flight test phase of the program.

Before commencing with the flight testing of a modified 707, a basic 707 was flight tested. The point was to acquire a set of baseline data for subsequent comparison with the results to be obtained from the modified aircraft. When the baseline data had been recorded and that phase of the testing was complete, the Quiet 707 Hush Kit was installed on the test aircraft. A comprehensive flight test program was conducted which included flutter and vibration, performance, aircraft flying qualities, engine operating characteristics, and of course, acoustic measurements.

The acoustic test program collected data for the approach and landing phase, sideline noise during takeoff and the takeoff climb out itself (Figure 18). The test procedures for noise measurements are very rigorous. A sophisticated microwave system was used to provide the pilot course tracking information so that he could fly the precise approach profiles and takeoff climb out profiles. This system also provided the onboard recorded data that was used in the acoustic analysis to define the airplanes positions relative to microphones. The noise data itself was recorded by a network of microphones placed along the center line under the aircraft flight path as well as off to each side.

When the flight test results had been analyzed, the results indicated that the aircraft met the FAR Part 36 Stage 2 requirements on approach using the planned 25^{o} landing flaps, on takeoff with a maximum break release gross weight of 321,000 pounds (a 13,200 pound reduction from basic 707 maximum takeoff weight), and was well under the sideline noise limit (Figure 21). These results were very close to those predicted based upon the ground test results conducted earlier in the year. The optimized solution had produced a Quiet 707 with a much improved noise footprint compared to the basic 707 aircraft (Figure 22).

Tracor Aviation

The results of the performance flight tests were equally favorable (Figure 23). With 25° flaps the Quiet 707 requires landing speeds only 6 knots higher than the unmodified 707 at maximum landing weight. The corresponding landing field lengths for the Quiet 707 were just a few hundred feet longer than the basic 707. This modest increase in field length will rarely be a limitation for the Quiet 707 in actual operations.

The culmination of the many months of design, manufacturing and testing of the Quiet 707 took place on February 22, of this year when the Federal Aviation Administration issued Supplemental Certificate SA2699NM certifying that the Quiet 707 had satisfactorily complied with all applicable aviation regulations (Figure 24).

With certification in hand, the production program is now well underway. Advanced production work was actually initiated in May of 1984. The production effort now is at full pace. The Hush Kit fabrication and assembly operations are being carried out at Tracor Aviation's manufacturing facility in Santa Maria, CA. and at Rohr Industries production facilities in Riverside and Chula Vista, CA. The installation of the Kits on customer aircraft is being accomplished at Tracor Aviation's facility in Santa Barbara, CA. The first aircraft will be completed and delivered this week with the second production modification already in work and planned for delivery by the end of this month. Thirty Quiet 707 aircraft will be delivered before the end of this year. A minimum of four Kits per month will be produced and installed during 1986.

The Quiet 707 is a successful example of the application of new technology to older aircraft. We are proud that our product will extend the life of a fine aircraft for many more years to come and in doing so have made it a good neighbor for the airport community.

NOTE: The following figures are those used in the presentation at the hearing.

KSI:cvs

The Problem

Jan 1, 1985 All Boeing 707 Aircraft are prohibited from operating in the United States due to non-compliance with FAR 36 as applied through Subpart E of FAR 91

Jan 1, 1988 707 Aircraft will be prohibited from operating in much of the rest of the world due to ICAO Annex 16 Chapter 2

Figure 1

Potential Solutions

Scrap the Aircraft and buy new models

Re-engine with new technology engines

Modify the nacelles with Hush Kits

Figure 2

An Optimized Solution

- Effective Acoustic Treatment to Existing Nacelle
- 25 Degree Landing Flaps
- Minor Change to Maximum Takeoff Weight

Figure 3

Quiet 707 Program Organization

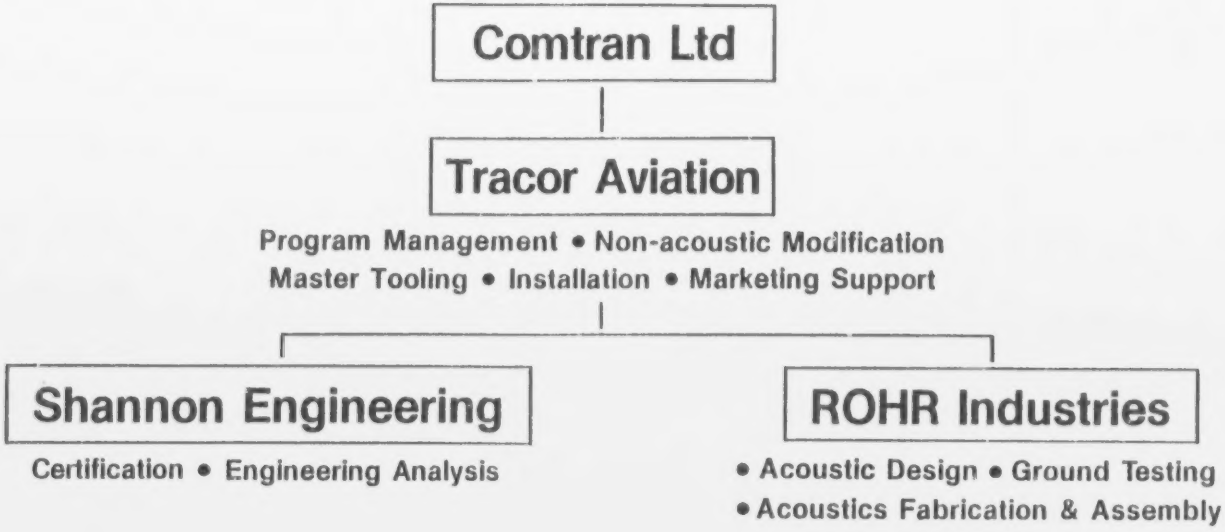


Figure 4

The Quiet 707 Nacelle

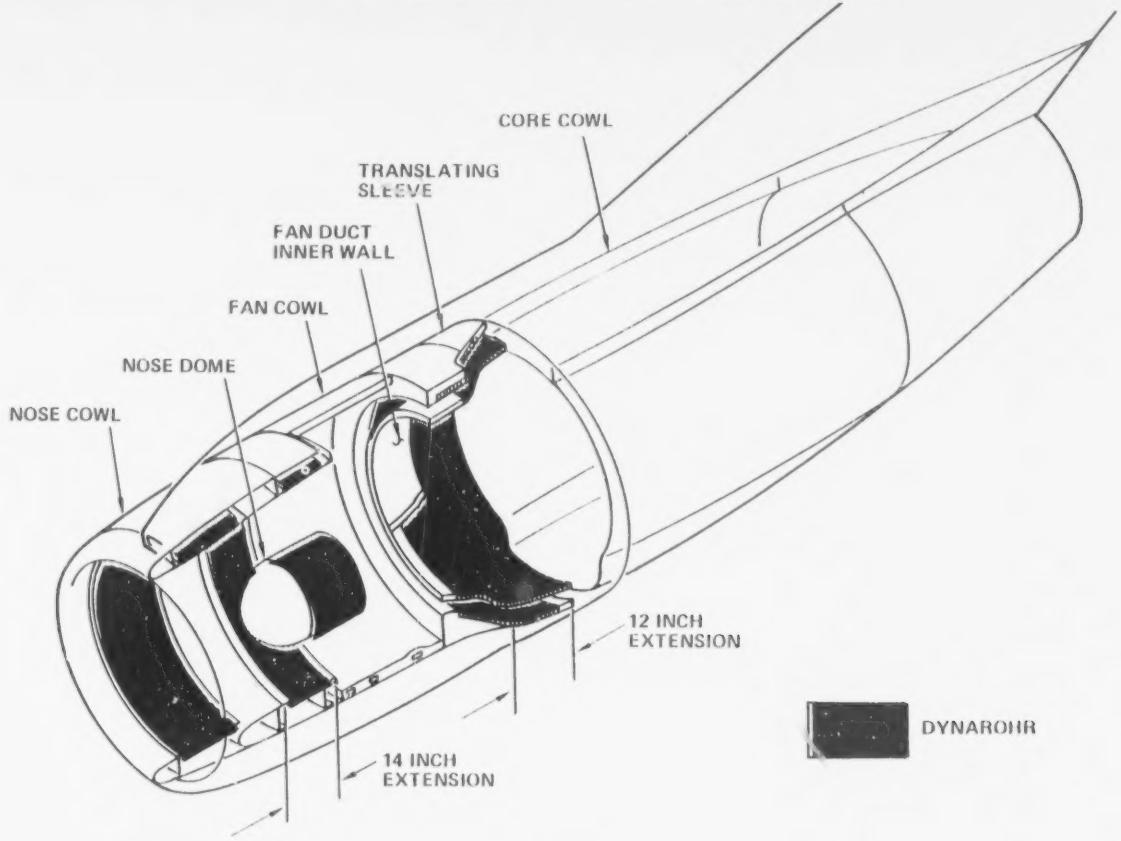


Figure 5

Typical DYNAROHR™ Panel

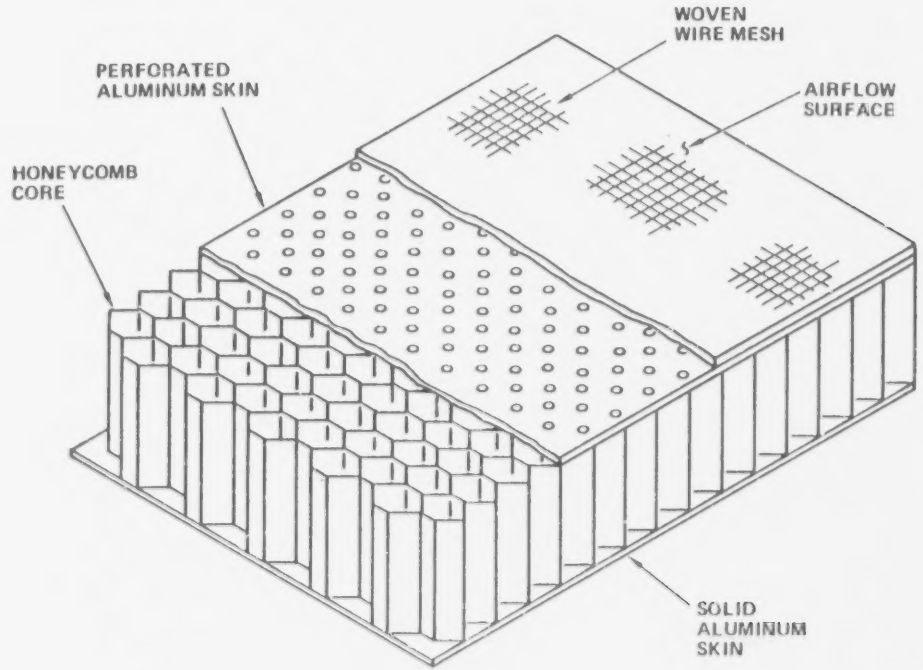


Figure 6

DYNAROHR™ Acoustic Treatment

- Structural bonded honeycomb sandwich with a stainless steel woven wire cloth bonded to an aluminum perforate face sheet
- Woven cloth produces a linear acoustic structure
- Smooth surface minimizes aerodynamic drag
- Acoustically efficient over wide frequency range

Figure 7

48-026 O-82—5

DYNAROHR™ Applications

Aircraft	Service Introduction		Components
737-200	(JT8D)	1975	Inlet Cowl Nose Dome
747	(JT9D-7Q)	1979	Engine Fan Case
MD80	(JT8D-209)	1980	Inlet Cowl
A310	(CF6-80A3)	1983	Inlet Cowl
A310	(JT9D-7R4)	1983	Inlet Cowl Fan Reverser
757	(RB211-535E)	1984	Inlet Cowl
A300-600	(JT9D-7R4)	1984	Inlet Cowl Fan Reverser
757	(PW2037)	1985	Engine Fan Case
A300-600	(CF6-80C2)	1986	Inlet Cowl

Figure 8

Modified Nose Cowl

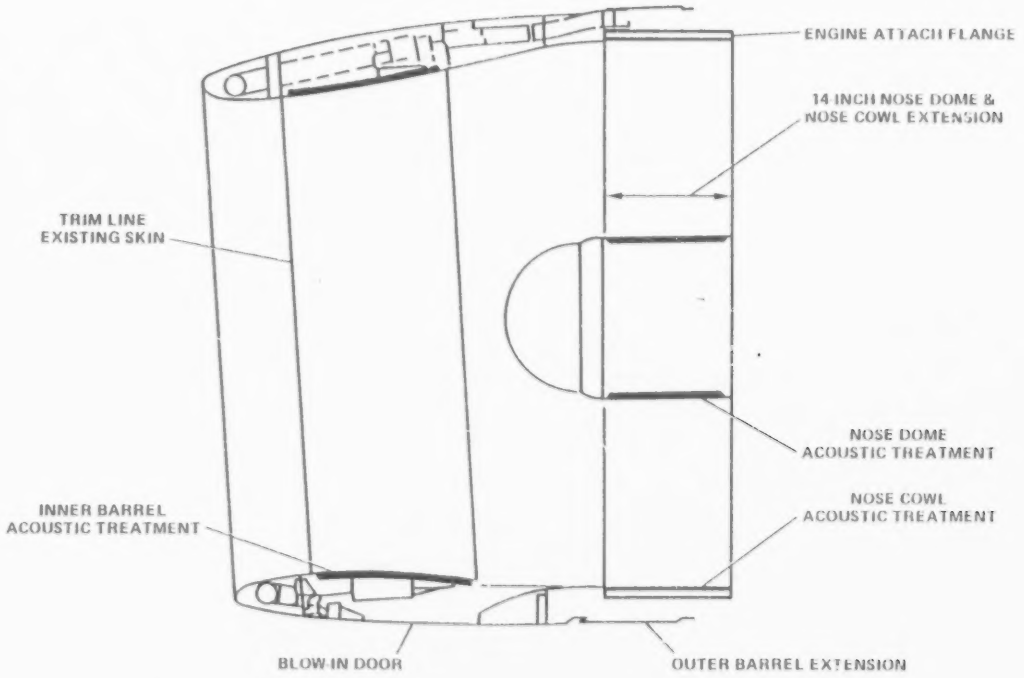


Figure 9

Figure 10 - Quiet 707 Nose Cowl showing DynaRohr™ inner liner and inlet extension

——Modified Fan Duct & Translating Sleeve——

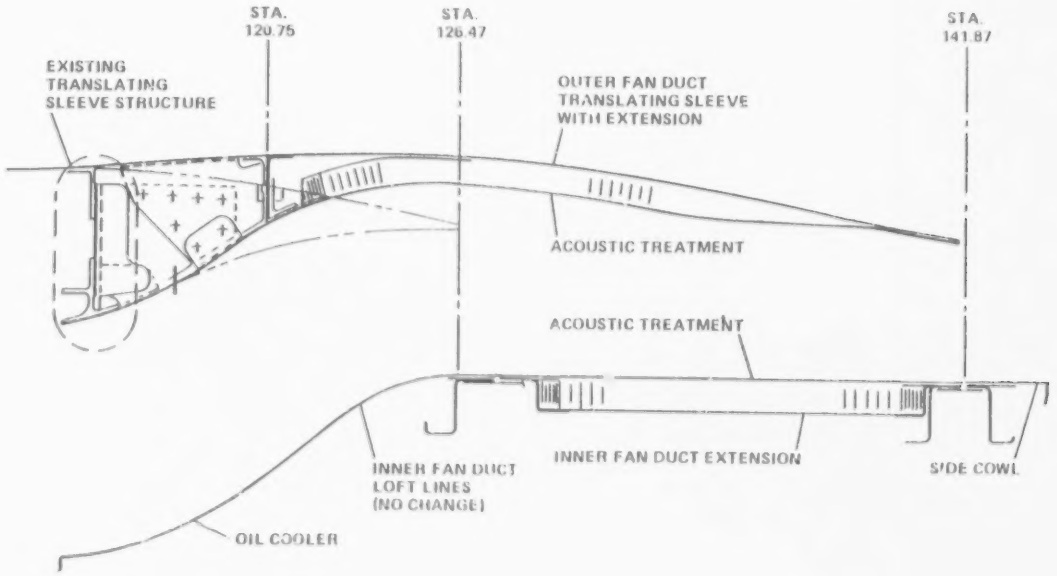


Figure 11

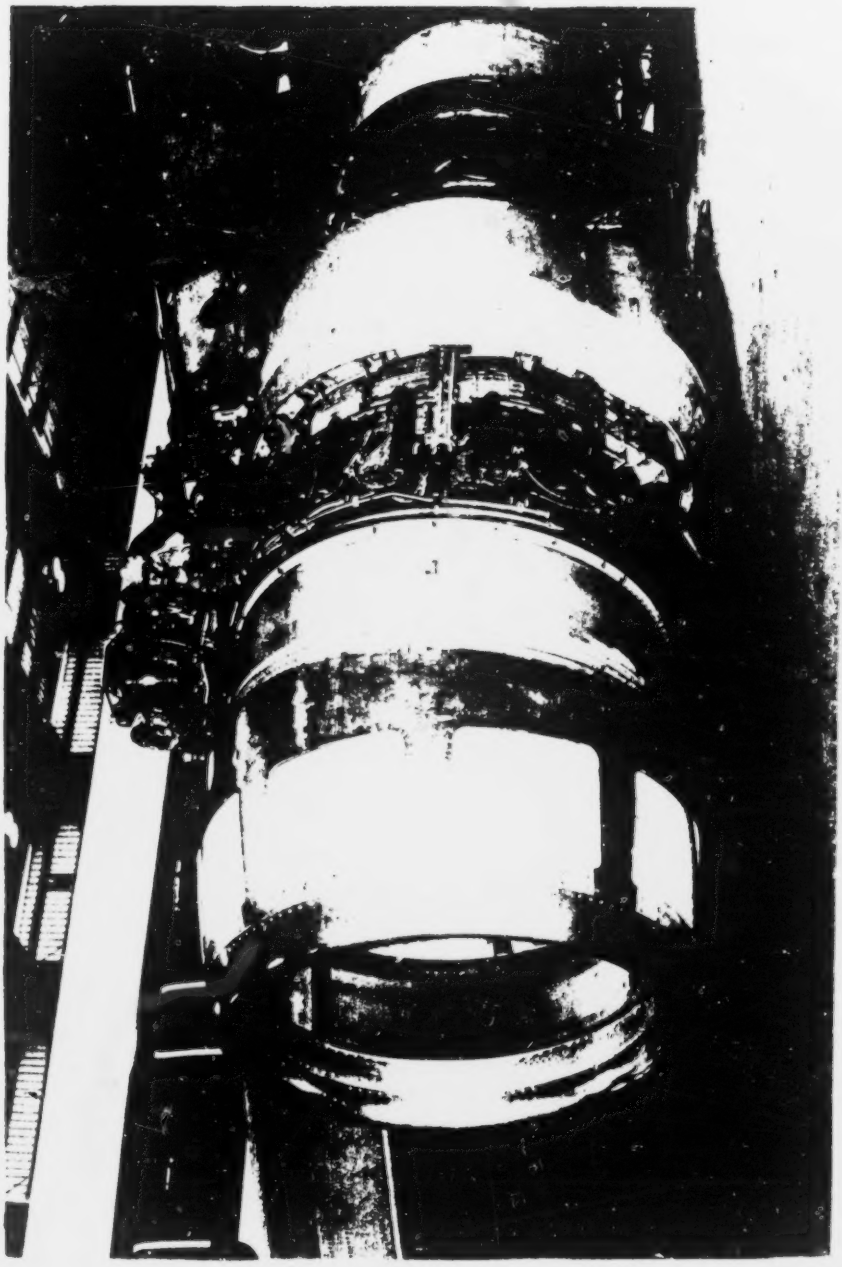


Figure 12 - Quiet 707 Nacelle with fan cowl door and side cowl door removed

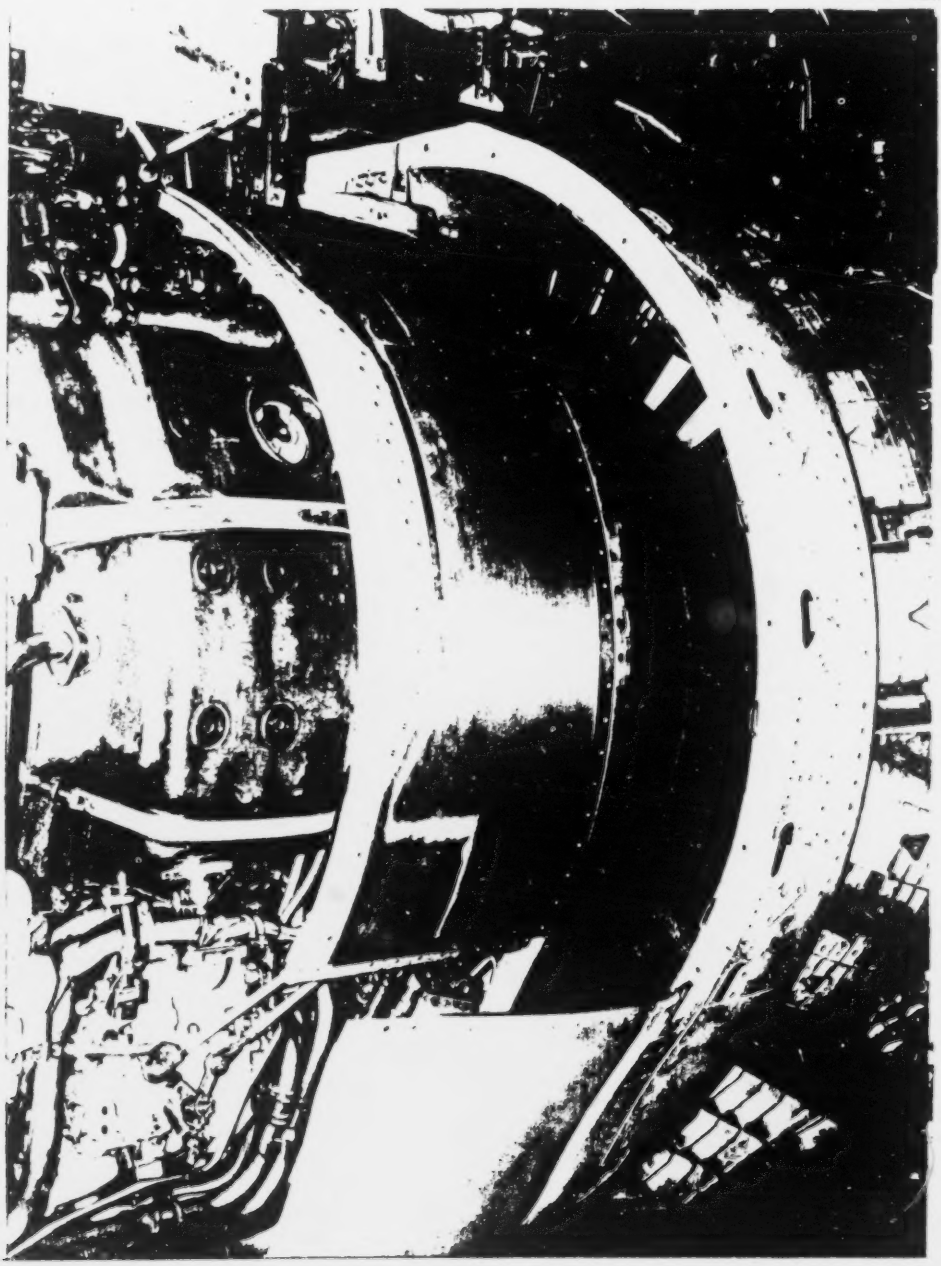


Figure 13 - Partially disassembled Quiet 707 Nacelle showing the upper right DynaRhor™ panel of the fan exit duct inner wall

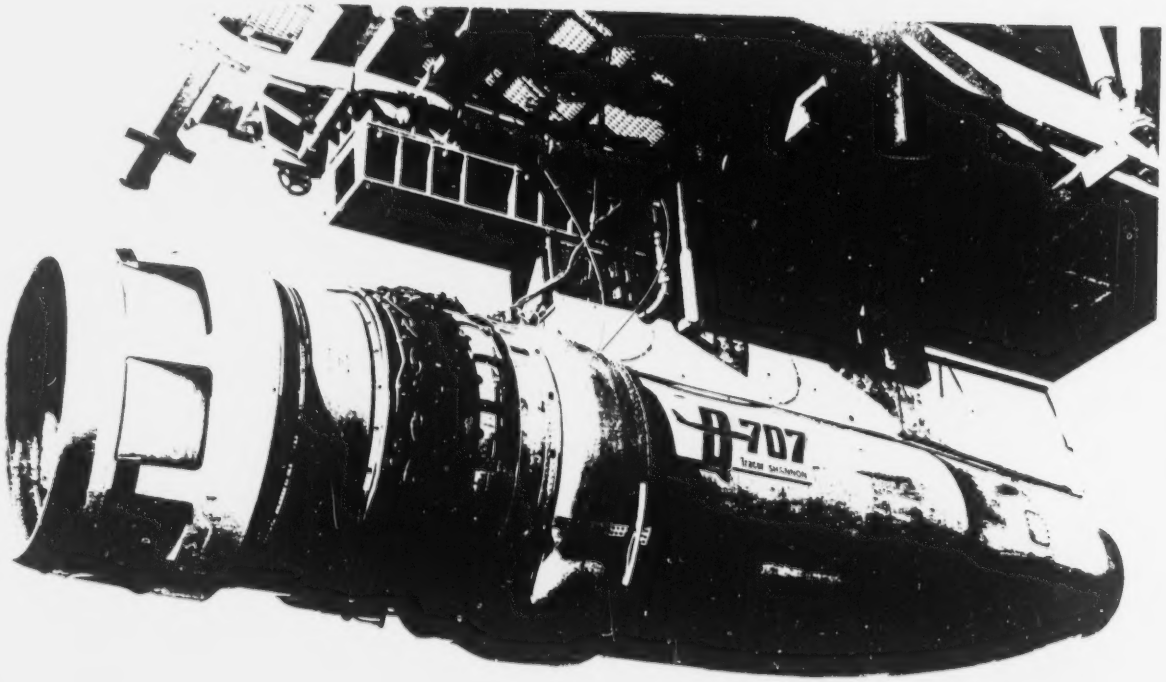


Figure 14 - Prototype Quiet 707 Engine/Nacelle in Rohr Industries ground test facility

ROHR B-60 Microphone Array

Ground Plane Microphones

150′ Radius 10° - 160° at 10° Increments = 16 MICS

Pole Microphones

150′ Radius 20°, 30°, 50°, 70°, 90°, 110°, 130°, 150°, 160° = 9 MICS

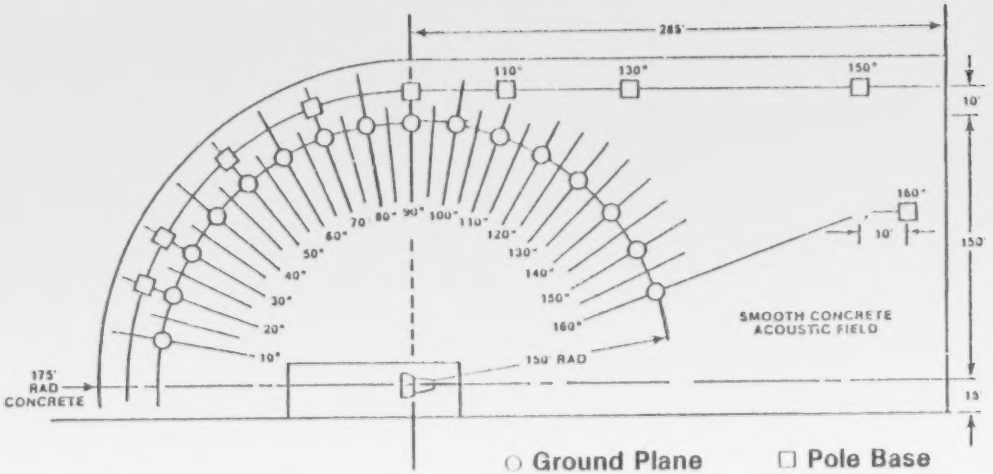


Figure 15

Figure 16 - Unmodified Boeing 707 during baseline flight tests

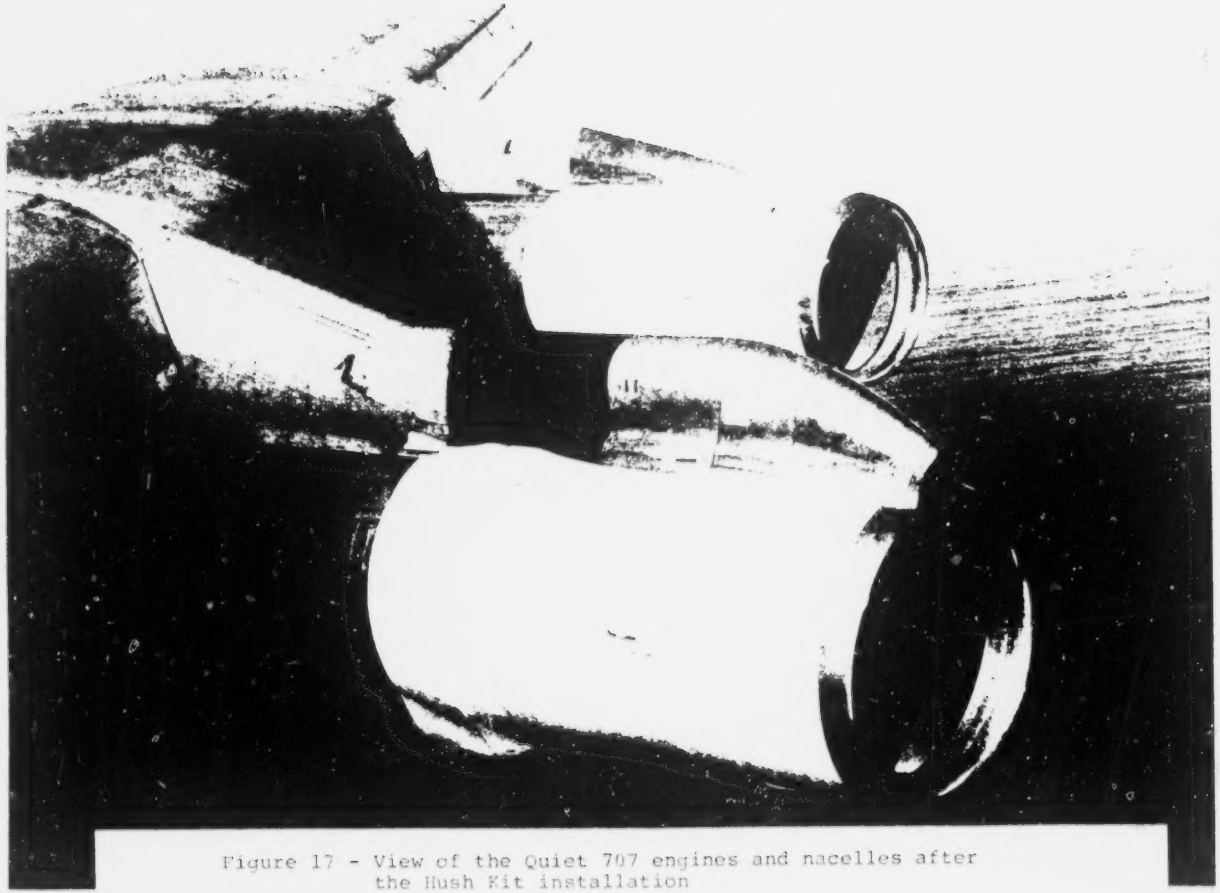


Figure 17 - View of the Quiet 707 engines and nacelles after the Hush Kit installation

FAA Noise Measurement Points

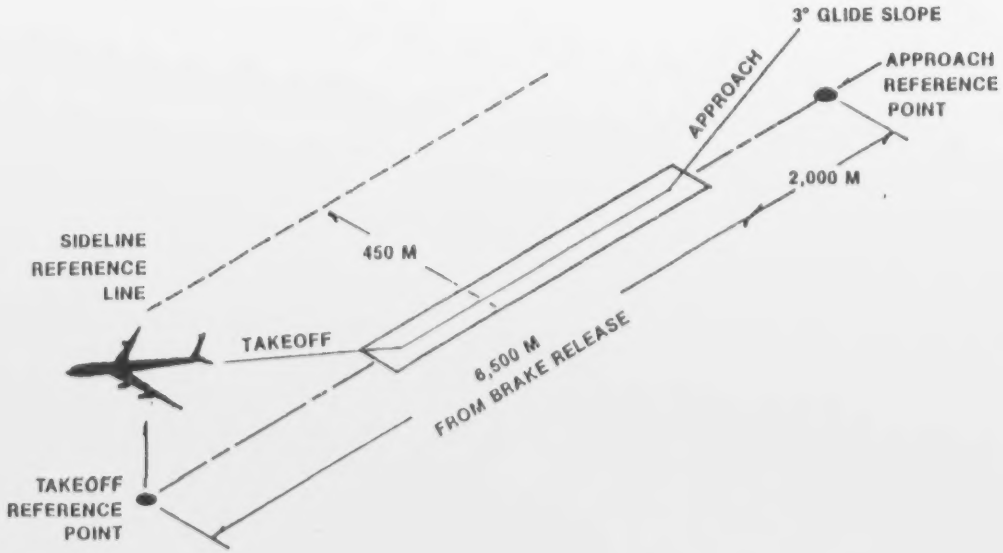


Figure 18

Figure 19 - Quiet 707 flying over microwave space positioning station during acoustic flight tests

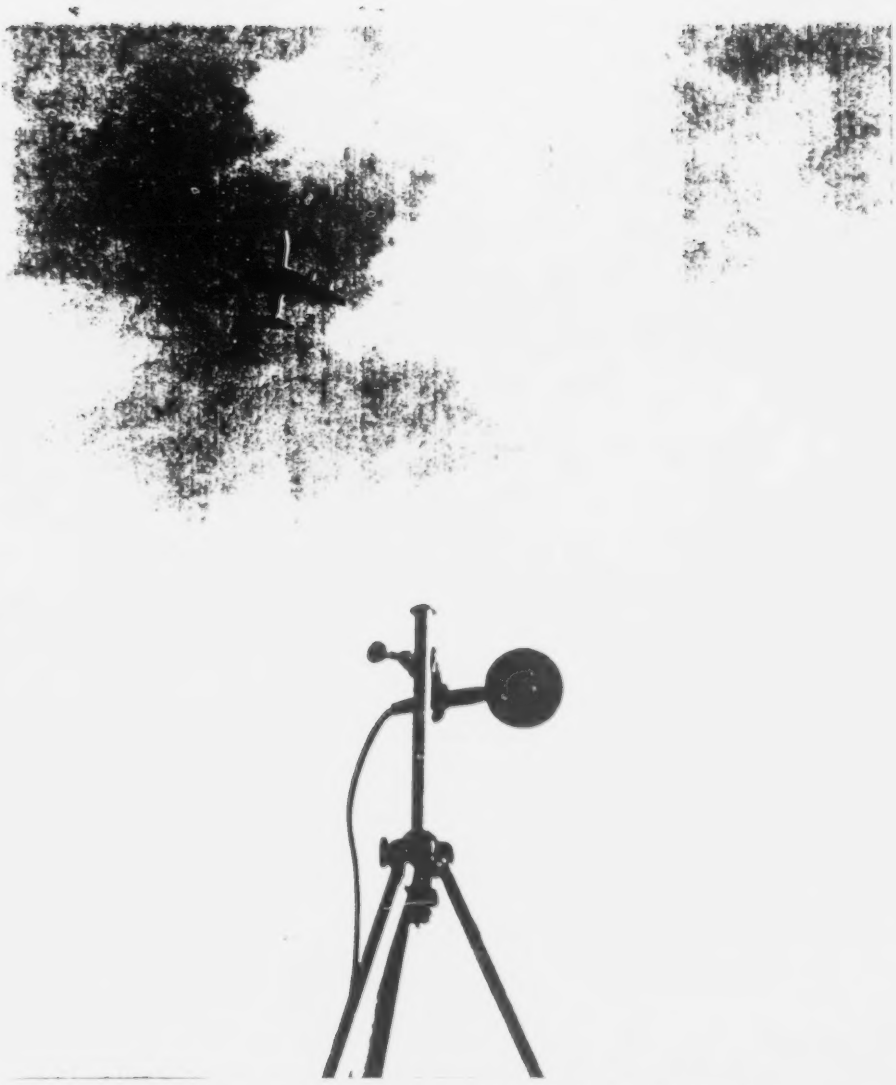


Figure 20 - Quiet 707 flying over microphone during acoustic flight tests

FAR PART 36
Certification Noise Levels

707-300B ADV/C
JT3D-3B
Tracor/SHANNON Quiet 707

TAKEOFF CONFIGURATION:
321,000 LBS. BRAKE RELEASE GROSS WEIGHT
FLAPS 14
T/C OFF

APPROACH CONFIGURATION:
247,000 LBS LANDING GROSS WEIGHT
FLAPS 25
T/C ON

EFFECTIVE PERCEIVED NOISE LEVEL-EPNdB*

MEASUREMENT LOCATION	FAR PART 36 STAGE 2 LIMIT	CERTIFICATION LEVEL
TAKEOFF-WITH CUTBACK	103.5	105.5
SIDELINE-WITH CUTBACK	106.2	99.3
APPROACH	106.2	105.9

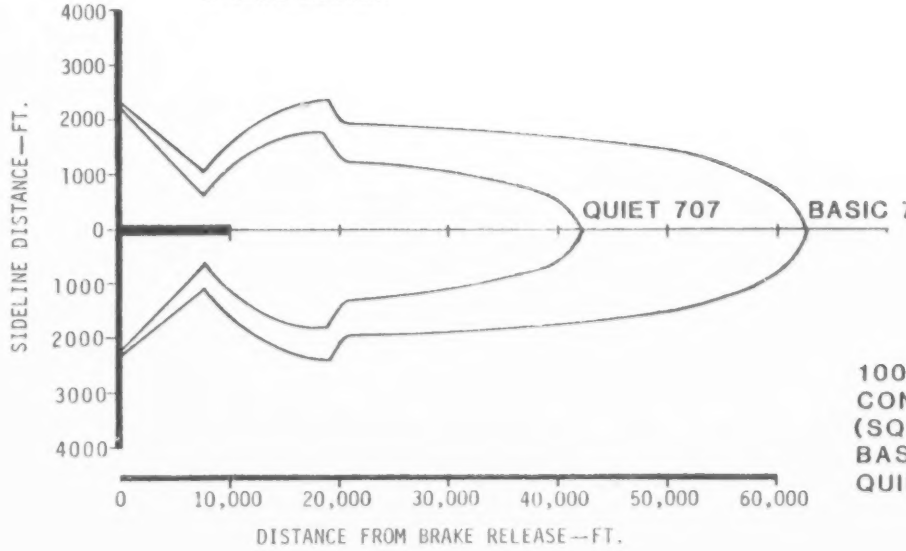
*77 F, 70% RH, SEA LEVEL

Figure 21

100 EPNdB CONTOURS

TAKEOFF:
- 320,000 LB. BRGW.
- FLAPS 14°
- T/C's OFF
- 1000 FT. CUTBACK TO 4% CLIMB GRADIENT

AMBIENT CONDITIONS:
- SEA LEVEL
- 77°
- 0 RUNWAY GRADIENT
- 0 WIND



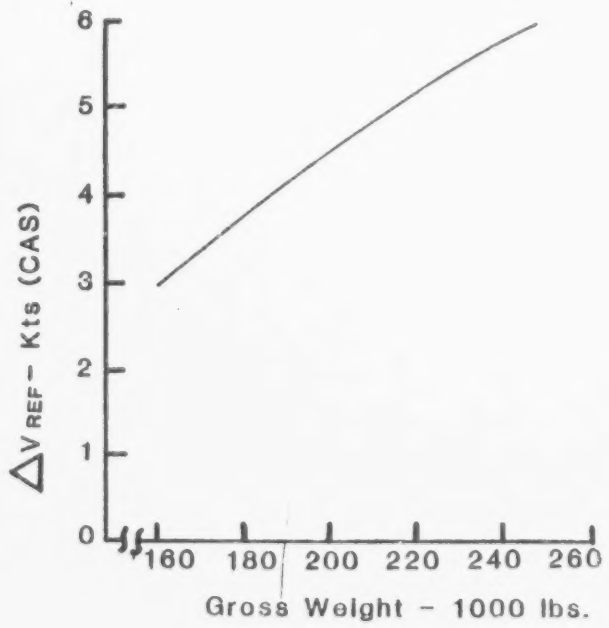
100 EPNdB CONTOUR AREA (SQUARE MILES)
BASIC 707 6.5
QUIET 707 3.2

Figure 22

Landing Performance

707-300 B ADV /C

Q707 INCREASE IN APPROACH SPEED OVER B707



Q707 INCREASE IN LANDING FIELD LENGTH OVER B707

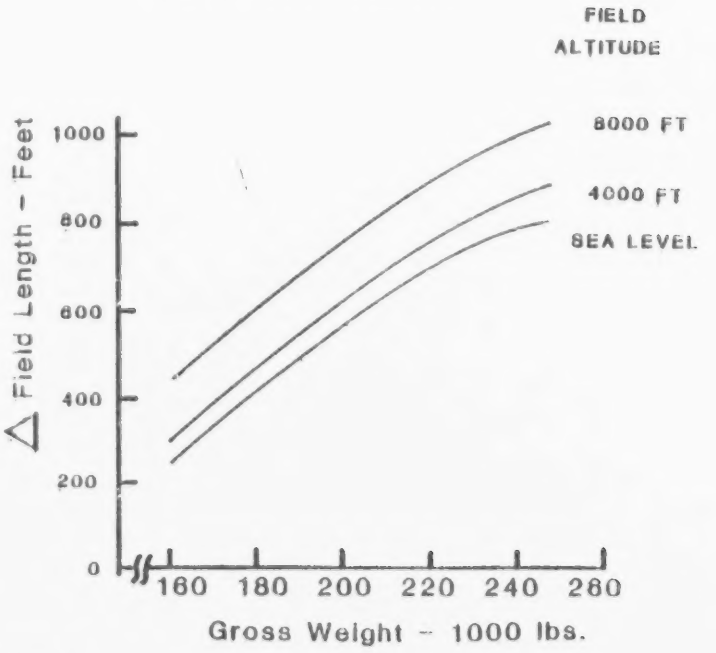


Figure 23

United States of America
Department of Transportation—Federal Aviation Administration

Supplemental Type Certificate

Number SA2699NM

This certificate, issued to Shannon Engineering

certifies that the change in the type design for the following product with the limitations and conditions thereto as specified hereon meets the airworthiness requirements of Part 4b *of the* Civil Air Regulations.

Original Product—Type Certificate Number: 4A26
Make: Boeing
Model: 707-300B (ADVANCED), 707-300C

Description of Type Design Change:
Modification of the Boeing Model 707-300B (ADVANCED) and 707-300C airplanes in accordance with the FAA approved Shannon Engineering Master Drawing List (MDL) Number JS1102001, Revision B, dated February 22, 1985, or later FAA approved revisions.

Limitations and Conditions:
The approval of this change in type design applies to the above aircraft models which are otherwise unmodified. This approval should not be extended to aircraft of these models that incorporate any other previously approved modification unless it is determined that the interrelationship between this change and any other modification will introduce no adverse effect on the airworthiness of these aircraft. A copy of this STC must be included in the permanent records of the modified aircraft. (Continued on Page 3)

This certificate and the supporting data which is the basis for approval shall remain in effect until surrendered, suspended, revoked, or a termination date is otherwise established by the Administrator of the Federal Aviation Administration.

Date of application: May 13, 1982 *Date issued:* March 6, 1985

Date of issuance: February 22, 1985 *Date amended:* March 6, 1985

By direction of the Administrator

Figure 24

(Signature)

Manager, Seattle Aircraft Certification Office
(Title)

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both.

This certificate may be transferred in accordance with FAR 21.47

Figure 29 - Quiet 707 taking off from Santa Barbara Municipal Airport.

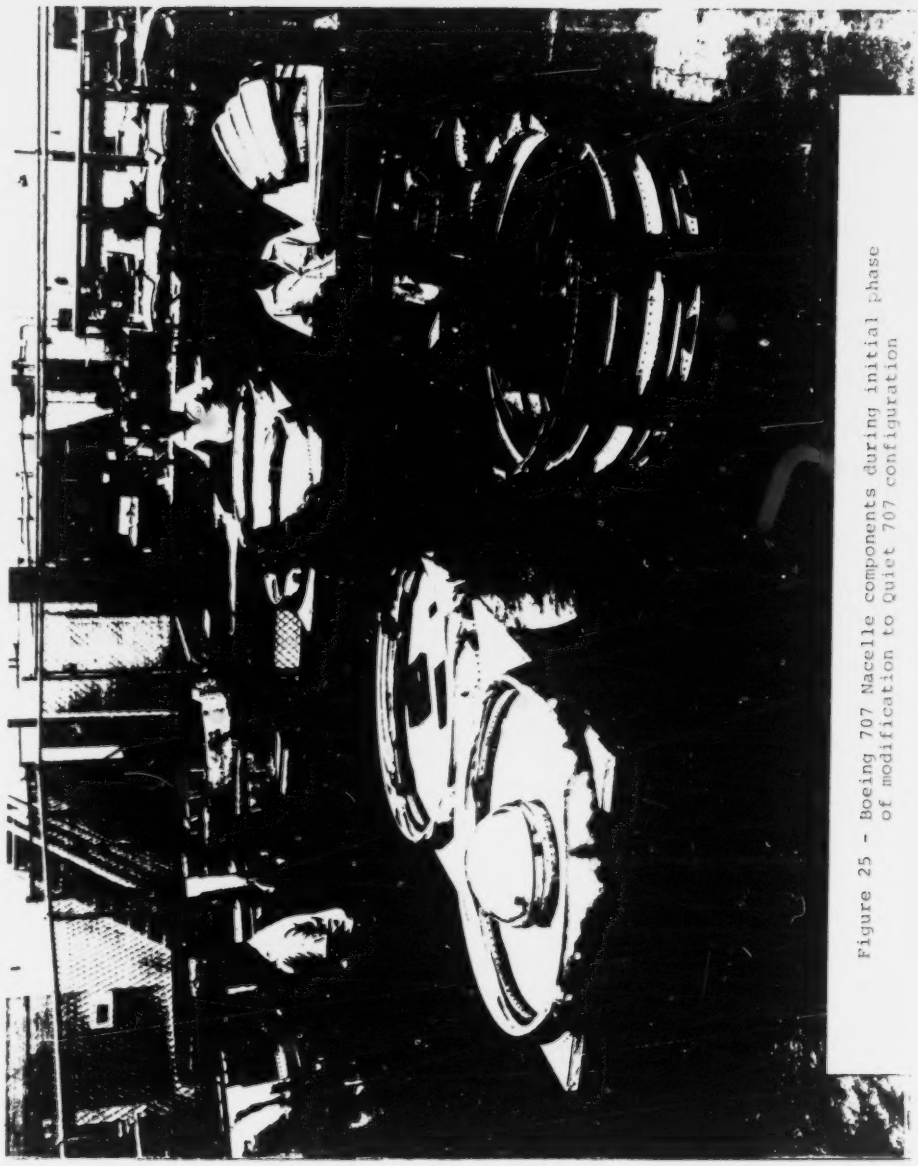


Figure 25 - Boeing 707 Nacelle components during initial phase of modification to Quiet 707 configuration

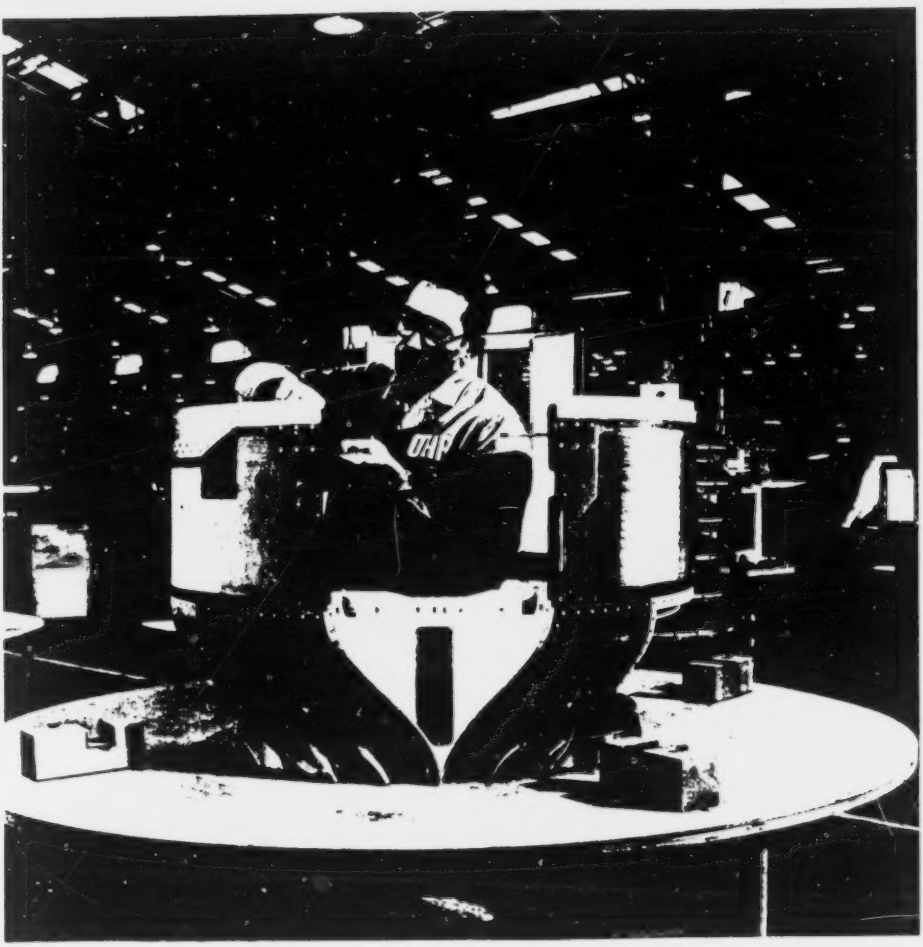


Figure 26 - Quiet 707 fan exit duct inner wall in final assembly at Rohr Industries

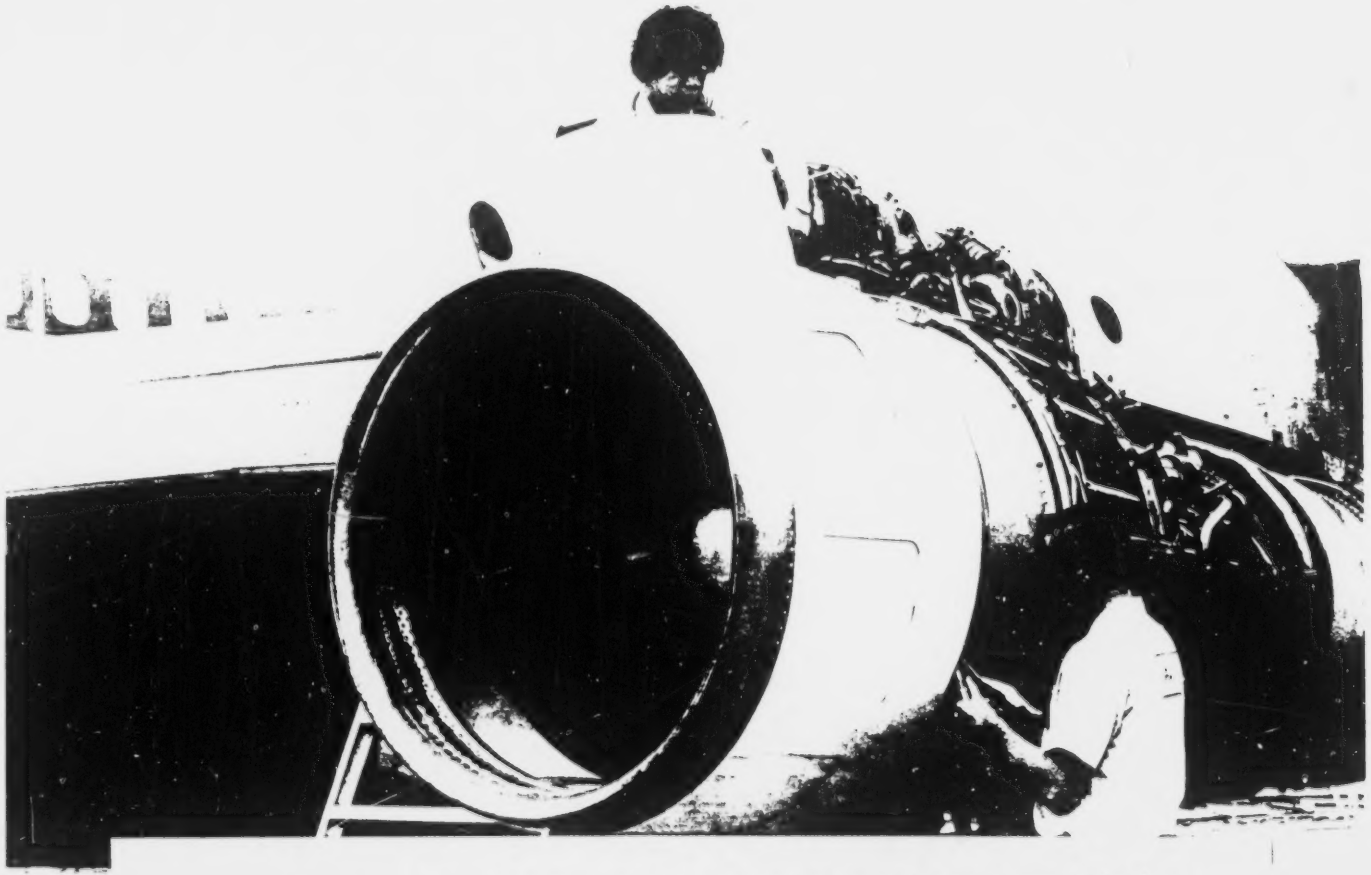


Figure 27 - Quiet 707 Nacelle kit being installed at Tracor Aviation

Delivery Status

First Production Delivery: April 1985

Minimum Deliveries 1985: 30

Planned Rate 1986: 5 Per month

Next Open Slot: March 1986

Figure 28

The CHAIRMAN. Thank you very much for your excellent testimony, all of you.

Mr. Lewis and I are going to have to go downstairs for a minute, and so I'm going to turn the chair over to Mr. Packard right now, until we get back.

Mr. PACKARD. Thank you, Mr. Chairman.

Let me ask you, on Tracor's procedures, how many 707's are still in service, or could be placed in service with appropriate measures taken?

Mr. IRWIN. Of all types of 707's just over 400. Many of those are not in active service today.

That includes the 707-100's. I don't believe that number includes the 720's, but it might. Our certification, at this point, applies to the 707-300, B advanced and C. Those are just about 330 worldwide.

We think that the total market for the aircraft will be in the range of 150 to 200.

Mr. PACKARD. Is the 707 still considered one of the more stable and better aircraft, and is that the reason that you are making an effort to keep them in service?

Mr. IRWIN. Well, first, it is a very fine aircraft; one that has a proud record of service, and the 707 and DC-8 meet what is called the long, thin route, long-range passenger load, say 140 to 180 passengers.

There are no other aircraft that have the particular range and payload combinations of those two aircraft, so they have become very important to operators like Equitoriana, LAB, Land Chile, Care Bear Cargo, and so on.

There are a lot of operators that find it unique to the particular route structures that they have. South Pacific Island Airways is another.

Mr. PACKARD. Are more foreign companies flying 707's than domestic?

Mr. IRWIN. There's only one domestic airline, and that doesn't even fly in the contiguous United States, and that's South Pacific Island Airways.

The others are all foreign airlines that are operating them, and charter operators, cargo operators, some corporate operators.

Mr. PACKARD. Will the kits be installed by the company, by Tracor or other companies?

Mr. IRWIN. We will install all of the kits this year, and well into next year. We do anticipate that as the customers shift from those that need to meet the U.S. regulatory requirements to those that are only having to face the ICAO requirements, outside of the United States, that there will probably be one licensed installation center in Europe; possibly one in Asia, but we haven't really looked into that.

Mr. PACKARD. If your monitors indicate that it does not meet stage 2 requirements totally, is it possible for further adaption of other techniques or technology to make them so that they would meet all of stage 2 requirements?

Mr. IRWIN. The aircraft does meet stage 2, and we have completed a very comprehensive acoustic test program meeting all of the

FAA requirements for testing and have demonstrated that the airplane is in full compliance with stage 2.

Mr. PACKARD. Oh, I see. I was under the impression that in some of your charts that there was, on takeoff, that they didn't meet all of the requirements.

Mr. IRWIN. I'm sorry; in order to meet stage 2, we've made some operating adjustments, reducing the takeoff gross weight and using the 25-degree flaps.

There are some means of making the aircraft acoustically slightly better. We are exploring eliminating this 13,200 pound weight restriction by certain additional treatment.

Mr. PACKARD. Will that alter your range of the aircraft?

Mr. IRWIN. That would give the aircraft greater range, better fuel load capacity, if they were going with full payload.

This is actually not a very significant restriction on the operators. It is very rare that they were operating at the full 333,600 pounds, anyway.

Mr. PACKARD. Economically, do you feel then, that the $2.5 million per aircraft, there will be little or no problem recouping that investment of the aircraft?

Mr. IRWIN. None whatsoever; it is a very reasonable price and economically suitable to the operators.

Mr. PACKARD. The gentleman from Pratt & Whitney, you indicated that—Dr. Goldberg, yes—you indicated, Dr. Goldberg, in your testimony, that a considerable amount of money and effort is being made to do your own research in terms of noise abatement, and you listed some impressive figures over the past 25 years.

Have you been coordinating those efforts with the efforts of NASA and our own research programs, Government research programs, or have you been doing that independently and what type of correlation has taken place?

Dr. GOLDBERG. It's been a well coordinated program, and a significant amount of the effort was funded by NASA in the early 1970's.

As of late, it's pretty much been our own effort, some of which—a lot of which—has been done with independent research and development funds.

However, we do, certainly, try and keep abreast and coordinated with any other work of a similar nature going on within this country and also outside of the country.

Mr. PACKARD. In your opinion, do you believe that it is going to be possible to meet stage 3 requirements within the foreseeable future?

Dr. GOLDBERG. Well, with the current airplanes in production, or the ones in service?

All the aircraft in production today will meet——

Mr. PACKARD. Will meet stage 3.

Dr. GOLDBERG. Well, I'm sorry; that's not quite right. The 737-200 does not, but other than that, they all meet stage 3, and all the future ones, other than that one should meet stage 3.

Mr. PACKARD. I can't remember whose testimony had a chart that showed that we should reach that by phasing out older aircraft.

Dr. GOLDBERG. That was a chart that indicated the composition of the current fleet; in other words, there are a lot of stage 2 air-

craft that are being operated today out in the fleet, and as time goes on, they normally would be replaced with stage 3 aircraft.

Mr. PACKARD. In your research at Pratt & Whitney, are there other techniques besides the acoustical treatments that could be done to older engines to reduce noise?

Dr. GOLDBERG. There are, there are. There are things like spacing and blade vanes, numbers. There is a lot of technology that we have, some of which we have already incorporated in engines like the refanned JT8D.

We've tried to take all the modern technology from the high bypass ratio engines and put it into this moderate or low bypass ratio engine, and one could continue to do that.

Mr. PACKARD. Perhaps I could ask Mr. Russell, who obviously Boeing has been involved in the aircraft industry for a long, long time and is certainly very prestigious in that industry, do you believe that there will be—well, let me rephrase.

Do you believe that the requirements, Federal requirements, in terms of, not only noise, but other environmental requirements, are not only achieveable, but realistic? And do you foresee in the future, that there may even be more stringent requirements upon the aircraft industry?

Mr. RUSSELL. I would say the current requirements certainly meet the dictate that Congress imposed on the FAA, that they be economically reasonable and technologically practical.

So the requirements are fair and equitable, but in several cases, exceedingly tight. The one I mentioned, the 747, we have some models today that do not meet stage 3.

They're not very far away from it; they're within a half decibel to maybe two.

Mr. PACKARD. For my own information, when were these criteria established, stage 1, 2, and 3, or did they all come on line at one time, or have they gradually developed and been imposed over a period of time? Could you brief me on the history of how the regulations have emerged?

Mr. RUSSELL. Yes, sir. Stage 1 is an airplane that has never met any noise requirement of any sort. It simply is a nonnoise certified, a nonnoise qualified airplane. It simply is all airplanes that do not meet either stage 2 or stage 3.

Stage 2 was imposed on the industry in 1969, December 1969. In terms of new airplanes, it later, as was mentioned earlier, in 1973 and 1974, was imposed on current production 727's and 737's and DC-9's.

Stage 3 was passed in 1977 to 1978, and that has been the design requirement that has been imposed for new airplanes since that time.

Mr. PACKARD. Is there any indication, or any concern, by the industry that there might be a stage 4 down the road another 4, 5, or 10 years?

Mr. RUSSELL. Yes, sir, that's always a concern.

Mr. PACKARD. Will the industry, itself, the private sector of the aircraft industry, significantly benefit, or will it be a significant cost burden to them to meet these requirements?

Obviously the cost of producing engines and aircraft, or retrofitting, that can meet the requirements will be passed on to the pur-

chasers of the vehicles themselves, and ultimately, they will be passed on to the riding public.

Does that affect the profitability of an airline, like Eastern or other airlines, or do they simply base their management decisions on these figures?

Mr. COOPER. Well, obviously it has significant impact on the airlines. It's a double-edged sword. One is the initial cost of procuring the necessary modification kits, or whatever they might be.

The secondary impact, of course, is the impact of having the airplane possibly out of service for a minimum of a couple of days, and in some cases, longer than that, to accomplish the modifications.

That's an airplane obviously not generating revenue. In the long term, obviously, as I stated earlier, we've been very cognizant of the need to keep pace with the noise regulations and also be a good neighbor in that respect.

We have to weigh all of our fleet decisions against those criteria.

Mr. PACKARD. Well, let me get to the bottom line.

Do you believe that the industry, itself, would find it either difficult or not justified to participate in the research costs, or should that be borne by NASA and the Federal Government?

Mr. COOPER. I'm sure the industry would find it difficult to participate because of the diversity of the equipment which we all have. I'm not sure that all of the technology is transferable to all the different fleets.

Perhaps the gentlemen from Pratt and Boeing could comment on that.

Mr. PACKARD. Particularly from Pratt, you have done some of your own research. Do you anticipate you will recoup that research by virtue of producing a better engine that is more marketable under our restrictions?

Dr. GOLDBERG. I don't think there's any question about that. I think in order for us to be competitive in the marketplace and sell our product, it's got to be quiet. It's got to be as good, if not better, neighbor than somebody else's product, and a lot of the fundamental research that we do goes across the board. It applies to most any kind of turbofan engine.

Mr. PACKARD. Over the next 5 years, if the budget for the research for these specific areas was reduced, or I believe they've been reduced over the last 2 or 3 years, if they continue to be reduced, or even phased out, do you think the private sector would be able, and willing, to pick up the research costs, or do you think that that would be a tragic mistake and would delay the implementation of stage 3?

Dr. GOLDBERG. Well, stage 3 is here, and we produce products today that meet stage 3. Now it may have a bearing on something beyond stage 3, if there is something that comes beyond stage 3.

Right at the moment, we have very little contract work in the noise technology area. It's basically our own independent research and development funds that we are spending.

I would think we'll continue that into the future.

Mr. PACKARD. Thank you, and I will return the chair.

The CHAIRMAN. Thank you. I'm sure you asked most of the questions, but let me ask you a question, both Pratt & Whitney and Boeing:

Do you think that we would have, or you would have produced engines and airplanes to reduce noise, out of the goodness of your heart, or do you think that it was the regulatory push primarily inspired by anxious or upset members of the public which caused this to take place?

Dr. GOLDBERG. I certainly think that that had a lot to do with it. Not necessarily the regulations, themselves, but just the pressure from the public and the operators of these aircraft.

The CHAIRMAN. Mr. Russell?

Mr. RUSSELL. I would have to say it's been a blend of each.

We've tracked expenditures in research and development for noise reduction from 1958, and that's 11 years before FAR 36 came into being.

In that time, from 1958 until now, we have spent somewhere between $250 and $300 million of Boeing funds on noise reduction research and development, immense amounts of money in some 5 peak years.

We certainly were dedicated to reducing noise before FAR 36 and the FAA regulations, and in a combination with those we, of course, have had additional impetus, so it's been a combination of both.

The CHAIRMAN. Do you agree with that, Mr. Cooper?

Mr. COOPER. Absolutely.

The CHAIRMAN. How much has Eastern paid in penalties, I wonder, in the last year on violations?

When you violate, let's say, a noise—well, let me just ask you this:

They have monitors at airports testing your noise all the time, I think. When you violate that what happens to you?

Mr. COOPER. I believe we are required notification, and we receive a notification that we have violated the noise parameters, whatever it would be, of the airport.

As indicated previously, that results, at Eastern, anyway, in the individual pilot being counseled on the fact that for some reason he exceeded the required noise levels.

I don't believe at this time we have received any financial impact as a result of a violation. To follow, from our point of view, is to maintain that safe departure, obviously, and also to maintain the good neighbor elements.

In counseling with the pilot they prove that, in fact, he was dealing with an emergency which resulted in him exceeding, or not being able to achieve the correct profile for noise abatement, I think that is accepted if it was an acceptable reason.

The CHAIRMAN. For example, on hot summer days, a fully loaded, stretched 727 really has to push it. It gets off the ground safely, but it has to keep that thrust, perhaps, at higher levels than it would ordinarily do and maybe that is true of other aircraft, as well.

But there are times when noise levels have to be violated in order to operate an aircraft safely, is that correct?

Mr. COOPER. I'm sure there is no intent to do that. We are very close, obviously, and the airplane will be noisier in those cited conditions; the higher altitude or high temperatures, the airplane is going to be operated at a higher power and the actual altitude is going to be achieved more slowly so the noise frame is going to be larger, yes.

The CHAIRMAN. One of the things that has been talked about with the FAA is the ability to deal with all these stage 2 aircraft, retrofitting the 727's, to make them go into stage 3 aircraft.

I don't know if Mr. Packard asked this question, or not, but is it technically feasible to retrofit stage 2 aircraft to meet stage 3 noise levels?

Is it financially feasible to do that; that is, most of the airplanes that fly at West Palm Beach Airport are, I would assume, at least at this stage, stage 2 aircraft; the 727 series, the 200 series and the hushed up 100 series, maybe, I don't know about that; the DC-9 aircraft; 737's.

Seventy-five percent of all airplanes flying do not meet stage 3 levels.

What can you do about that, if anything? That is where most of the complaints are going to come; either one of you gentlemen.

Mr. RUSSELL. We do not, at this point in time, have in hand a fix for either the 727's in operation, or 737's, that would technically qualify them for stage 3.

I guess, technically, anything can be done in terms of reengining or using a refan engine, or something like that.

Economically, to fix the existing stage 2 fleet and convert it entirely to stage 3 would be an immense program, and I think what the airlines would eventually rather do, and what we are presently in the process of doing, is replacing those airplanes, rather than fixing up the old airplanes.

Technically, it would be extremely difficult, as well as economically maybe even impossible, to take the existing airplanes and convert them to stage 3.

The CHAIRMAN. Now, the DC-8's that have been reengined with the CFM56 engines, do they meet stage 3 requirements?

Mr. RUSSELL. Yes, sir, they do.

The CHAIRMAN. So it is conceivably technically possible to reengine these airplanes?

Mr. RUSSELL. That's correct. In that case, I think it was marginally economic to do it.

The 707, which we also tested at one time, and offered to the carriers, with a reengined CFM56, the same as the DC-8, was judged economically not viable, and therefore the airlines did not buy that airplane.

The CHAIRMAN. What, more than anything else, caused the airlines to buy the stage 3 airplanes?

Some of this may be self-evident, but Eastern has had a lot of financial problems over the last several years.

You've got some new generation airplanes, however. What's going to cause you to buy these new airplanes?

Would it be a regulatory push by the FAA, saying that by 1995 all airplanes must meet stage 3, or would it be more traffic, good economy, all of the above, or none of the above?

Mr. COOPER. Well, it's probably all the above, although to a degree, our latest motivation has obviously been efforts to conserve fuel, especially with the fuel prices we were experiencing 3 years ago.

That is somewhat alleviated now, but I guess there's an anticipation that that won't sustain itself much longer.

As a consequence, all of the stage 3 aircraft offer those economies of operation, the 757 especially, and that's a major motivator.

As I said, the reengining of our 757 from the C version of the engine to the E4 is motivated by not only fuel conservation, but noise is an added bonus in this case.

The CHAIRMAN. Thank you. Mr. Lewis.

Mr. LEWIS. Thank you, Mr. Chairman.

Mr. Cooper, I'm curious as to why Eastern would spend $23 million to modify the 757's when they already met the stage 3 requirements.

Mr. COOPER. Again, that's the other side of the coin; that's the fuel side. Those engines promise to give us between 8 and 10 percent more fuel economy than the current C version engines, and it happens to be quieter, also, because of the redesign of the fan section and the engine.

Mr. LEWIS. Do you agree with Mr. Russell's statement, and it may put you on the spot a little bit, that we're going to have all stage 2 aircraft out of the business by 2010 and we're going to have stage 3 aircraft operating?

Mr. COOPER. Well, I'm not sure exactly whether Eastern's fleet planning takes us out to 2010 right now, but in all probability, the airplanes in our fleet, which are at stage 2 today, are for the most part, aging.

So by 2010 I think they will have left our fleet. The concern, I guess, would have to be where they go from our fleet, and that's something we all have to answer.

Mr. LEWIS. I think it's fair to compliment Eastern for the amount of investment they've made in quieting their aircraft over the years.

Mr. COOPER. Thank you.

Mr. LEWIS. Particularly flying the congested areas in the Northeast corridor and down the eastern coast like they do.

I'd like to also ask Mr. Cooper, do you believe the goal of reducing airport noise to the level of ambient noise of the community, as Mr. Kayten brought out, is achievable?

Mr. COOPER. Oh, I think it is achievable; there's no question about it. The technology has been moving pretty well for the last 20 years.

Obviously it's not an inexpensive area of research and it's not inexpensive to incorporate technology, either in new airplanes or in existing airplanes.

But certainly it would relieve the airlines of some of the criticism that it receives today for violating peoples' space, if you like, polluting the air with noise.

Mr. LEWIS. Mr. Irwin, since the hush kits, themselves, are not enough to meet stage 3 noise limits, what assurance do we have that airplanes will take the necessary second and third steps, such

as the 25 degree flap, high speed landing and the gross weight adjustments at takeoff and that sort of thing?

Mr. IRWIN. It's really no different than any other aspect of the airline being obligated to follow its flight manual.

These procedures are a part of the FAA approved flight manual, and if the operator does not operate the aircraft in accordance with that flight manual and is in violation, then the necessary legislative or executive—the necessary laws—will be applied to see that he either does, or he will go out of business.

It would be no different than whether they're going to overload their aircraft and go out of an airport with a higher weight than they're certified for.

The flight manual is filled with rules. You must abide by the following things if you're going to operate this aircraft.

In the case of the quiet 707 hush kit, the takeoff weight is limited, and the 25 degree flaps is required as a normal landing flap setting.

Mr. LEWIS. I'd like to ask you, Dr. Goldberg, the same question I asked Mr. Cooper on the reduction of airport noise to the level of ambient noise in the community.

Do you think this is achievable?

Dr. GOLDBERG. My own feeling is probably not, but I'm not too well qualified to really comment on that area.

I don't know too much about airports, to be honest. You know, my profession is very much like the medical profession. We're all specialists and we all have our own little niche that we work in.

So I've kind of got blinders on most of the time. It sounds to me like it's going to be extremely difficult.

In order to eliminate noise from an engine, for example, you would have to make a perpetual motion machine, and I don't think that's going to happen.

Unless the airport boundaries grow substantially, I would have difficulty believing that, at least in the near future, the next 10 or 15 years, that we're going to come anywhere near that.

Mr. LEWIS. Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. I want to thank all the witnesses today. This has been a most productive hearing, in terms of both understanding where NASA is going with their research, where the FAA is going on the regulatory side of the picture, and where the industry is going in terms of trying to develop new generation aircraft engines, and the airlines, themselves, in terms of operating in a financially secure base, at the same time recognizing the public's desire to have quieter airport areas.

From a congressional perspective, I would only say it twofold: (1) That Mr. Lewis has repeatedly brought to the attention of this subcommittee the need for congress to keep pressure on the agency, the administration, as well as the industry, to continue to produce quieter airplanes and to take the necessary steps to get aircraft noise down.

This subcommitte will, over the next year or so, as we engage insight into the FAA, continue to monitor that, to press for technology development, but we are also always cognizant of the fiscal realities, particularly in the time period that we are in, and with

some of the carriers' economic conditions of moving ahead so precipitously that they can find themselves in a chaotic situation.

The one thing that I think we have learned at this hearing, and at previous testimony during the last few months, is that the effect of airline deregulation is much greater than we ever thought it was going to be in terms of what it's going to do to the industry.

I guess one of my fears is that airline deregulation is going to keep a generation of airplanes in business for a long time, that we never expected to stay for a long time, part of which because the Boeing Co. makes such good airplanes.

That's going to mean that noise is going to be a continued problem in a lot of airports in this country.

The pressure is not only going to be to get new airplanes on board, but how to deal with these old airplanes, whether we hush them up through adapter kits, whether we reengine them, or what.

So we will continue to monitor that, and I'm sure that there will be a good spirit of cooperation between industry and the Government as we deal with these issues in the years to come.

We appreciate the opportunity of coming down here. We appreciate the hospitality of Congressman Lewis, as well as the county commission here in Palm Beach.

The hearing stands adjourned.

[Whereupon, the subcommittee was adjourned at 12:25 p.m.]

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